This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

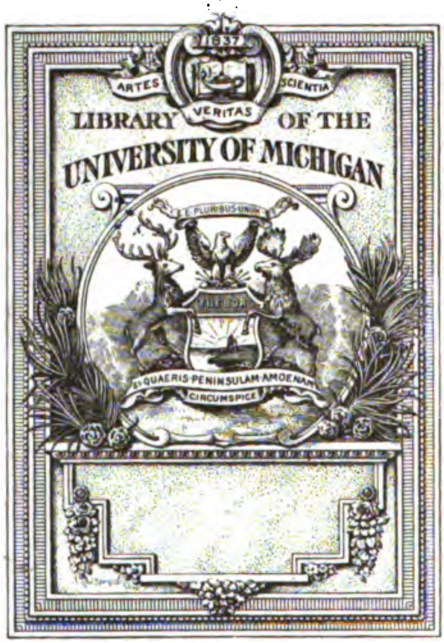
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at http://books.google.com/

69556

Digitized by Google


1837
ARTES
VERITAS
SCIENTIA
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
E PLURIBUS UNUM
TUEBOR
SI QUAERIS PENINSULAM AMOENAM
CIRCUMSPICE

Astro
VK
555
.A512
1880

V.

ASTRO
OBS.
VK
555
.B795
1880

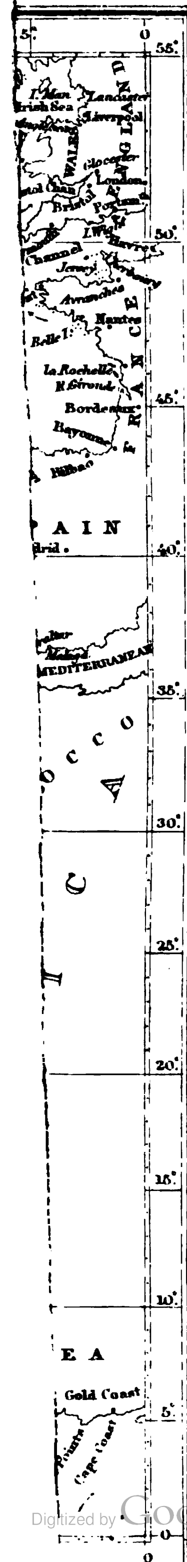
Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google



Digitized by Google

9.534

THE

NEW AMERICAN

PRACTICAL NAVIGATOR:

BEING AN

EPITOME OF NAVIGATION;

CONTAINING ALL THE

TABLES

NECESSARY TO BE USED WITH THE NAUTICAL ALMANAC

IN

DETERMINING THE LATITUDE, AND THE LONGITUDE BY LUNAR OBSERVATIONS,

AND

KEEPING A COMPLETE RECKONING AT SEA;

ILLUSTRATED BY

PROPER RULES AND EXAMPLES.

THE WHOLE EXEMPLIFIED IN A JOURNAL,

KEPT FROM BOSTON TO MADEIRA,

IN WHICH

ALL THE RULES OF NAVIGATION ARE INTRODUCED:

ALSO,

THE DEMONSTRATION OF THE USUAL RULES OF TRIGONOMETRY; PROBLEMS IN MENSURATION, SURVEYING, AND GAUGING; DICTIONARY OF SEA TERMS; AND THE MANNER OF PERFORMING THE MOST USEFUL EVOLUTIONS AT SEA:

WITH

AN APPENDIX,

CONTAINING

METHODS OF CALCULATING ECLIPSES OF THE SUN AND MOON, AND OCCULTATIONS OF THE FIXED STARS; RULES FOR FINDING THE LONGITUDE OF A PLACE BY OBSERVATIONS OF ECLIPSES, OCCULTATIONS, AND TRANSITS OF THE MOON'S LIMB OVER THE MERIDIAN; ALSO A NEW METHOD FOR FINDING THE LATITUDE BY TWO ALTITUDES.

BY NATHANIEL BOWDITCH, LL. D.,

Fellow of the Royal Societies of London, Edinburgh, and Dublin; of the Astronomical Society in London; of the American Philosophical Society, held at Philadelphia; of the American Academy of Arts and Sciences; of the Connecticut Academy of Arts and Sciences; of the Literary and Philosophical Society of New York; Corresponding Member of the Royal Societies of Berlin, Palermo, &c.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1880.

University of Michigan

Digitized by Google

NOTICE.

The copyright of The New American Practical Navigator, by the late Dr. Nathaniel Bowditch, having become the property of the government, under the provisions of section 2 of "An act to establish a hydrographic office in the Navy Department," approved June 21, 1866, the present edition of this work is published by the Bureau of Navigation.

Future changes in The New American Practical Navigator, with a view to its improvement in certain respects, are contemplated; but a new edition having been called for to supply the immediate demands of navigators, the work is now printed from the original stereotype plates as used in the last edition, (1867,) with the exception of a few corrections on the plates of discovered errors in the tables.

BUREAU OF NAVIGATION, *August* 1, 1868.

Digitized by Google

CORRECTIONS AND ADDITIONS

TO GEOGRAPHICAL POSITIONS IN TABLE LIV. OF BOWDITCH'S NAVIGATOR, EDITION OF 1851.

Kindly furnished by Dr. Bache, Superintendent of the U. S. Coast Survey, by authority of the Treasury Department

	NAME OF PLACES.	Latitude.	Longitude.	REMARKS.
		D. M.	D. M.	
Maine.	Cape Elizabeth West Light	43 33.8	70 11.8	
	Cape Elizabeth East Light	43 33.9	70 11.7	
	Wood Island Light	43 27.4	70 19.4	
	Agamenticus Hill	43 13.4	70 41.2	Trig. Point of C. S.
Massachusetts.	Plum Island East Light	42 48.4	70 48.7	Newburyport Lights.
	Plum Island West Light	42 48.4	70 48.8	
	Beverley Spire	42 43.0	70 52.4	Spire with Turrets.
	Ipswich East Light	42 41.1	70 45.6	
	Ipswich West Light	42 41.1	70 45.8	
	Squam Light	42 39.7	70 40.6	
	Straits mouth Island Light	42 39.7	70 35.0	
	Thatcher's Island South Light	42 38.2	70 34.2	Cape Ann.
	Thatcher's Island North Light	42 38.3	70 34.2	
	Ten pound Island Light	42 36.1	70 39.6	
	Eastern Point Light	42 34.8	70 39.5	
	Baker's Island Light	42 32.2	70 46.8	
	Salem, Tall Spire	42 31.2	70 53.6	
	Marblehead, Black Top Church	42 30.4	70 50.5	
	Nahant Hotel	42 25.1	70 54.0	
	BOSTON, State-House	42 21.5	71 03.5	
	Cambridge Observatory Dome	42 22.9	71 07.4	
	Bunker Hill Monument	42 22.6	71 03.3	
	Scituate Light	42 12.3	70 43.6	
	Boston Light	42 19.6	70 53.1	
	Long Island Light	42 19.8	70 57.1	Boston Bay.
	Plymouth Light	42 00.2	70 35.7	Gurnet South Light
	Race Point Light	42 03.7	70 14.3	
	Cape Cod Light	42 02.4	70 03.3	Highland Light.
	Long Point Light	42 02.0	70 09.8	
	Wellfleet Light	41 55.8	70 01.7	
	Billingsgate Point Light	41 51.6	70 03.9	
	Nausett Centre Light	41 51.6	69 56.7	
	Nausett South Light	41 51.1	69 56.6	
	Chatham South Light	41 40.2	69 56.6	
	Monomoy Light	41 33.5	69 59.3	
	New Bedford Light	41 35.5	70 53.7	Clark's Point Light
	Cape Pogue Light	41 25.2	70 26.7	
	Great Point Light	41 23.4	70 02.4	Nantucket.
	Brant Point Beacon	41 17.4	70 05.2	
	Sankaty Head Light	41 17.0	69 57.6	
	Nantucket Harbor Light	41 16.4	70 04.4	
	Nantucket Old South Shoal	41 05.5	69 50.0	Eastern Spot.
	Nantucket Old South Shoal	41 04.2	69 51.4	Western Spot.
	Davis' New South Shoal	40 58.0	69 51.5	Nantucket.
	Fishing Rip, 5½ fath.	41 03	69 26	
	" " " "	41 07.5	69 29	
	Barnstable Light	41 43.3	70 16.5	
	Point Gammon Light	41 36.5	70 15.6	
	Edgartown Light	41 23.4	70 29.8	

Digitized by Google

TABLE LIV.

Corrections and Additions.

State	NAME OF PLACES.	Latitude. D. M.	Longitude. D. M.	REMARKS.
Massachusetts.	West Chop Light	41 28.9	70 35.8	
	Nobska Light	41 30.9	70 39.0	
	Bird Island Light	41 40.1	70 42.7	
	Tarpaulin Cove Light	41 28.1	70 45.1	
	Ned's Point Light	41 39.0	70 47.4	
	Palmer's Island Light	41 37.6	70 54.2	
	New Bedford, Baptist Spire	41 38.2	70 55.3	
	Round Hill Light	41 32.3	70 55.0	
	Cuttyhunk Light	41 24.8	70 56.7	
	Gay Head Light	41 20.9	70 49.8	
	No Man's Land	41 15.2	70 48.5	Trig. Point of C. S.
Rhode Island.	Newport Spire	41 29.2	71 18.5	
	Goat Island Light	41 29.6	71 19.3	
	Nayat Light	41 43.5	71 20.0	
	Warwick Light	41 40.0	71 22.4	
	Wickford Light	41 34.2	71 26.0	
	Providence, Baptist Church	41 49.6	71 24.2	
	Dutch Island Light	41 29.8	71 23.9	
	Beavertail Light	41 26.9	71 23.6	Rhode Island Light.
	Point Judith Light	41 21.6	71 28.6	
	Watchill Light	41 18.2	71 51.2	
	Block Island Light	41 13.4	71 34.2	
Connecticut.	Stonington Light	41 19.6	71 54.0	
	Mystic Light	41 19.0	71 59.0	
	Saybrook Light	41 16.2	72 20.3	
	Little Gull Island Light	41 12.3	72 06.1	
	New London Light	41 19.0	72 05.1	
	Falkner's Island Light	41 12.7	72 38.9	
	New Haven Light	41 14.9	72 53.9	
	Stratford Point Light	41 09.1	73 05.9	
	Black Rock Light	41 08.5	73 12.7	
	Sheffield Island Light	41 02.9	73 24.8	
	Captain's Island Light	40 58.9	73 37.1	
New York.	Plum Island Light	41 10.4	72 12.4	
	Montauk Light	41 04.2	71 51.1	
	Cedar Island Light	41 02.4	72 15.3	
	Oldfield Point Light	40 58.6	73 06.8	
	Eaton's Point Light	40 57.2	73 28.4	
	Sands Point Light	40 51.9	73 43.5	
	NEW YORK, City Hall	40 42.7	74 00.1	
	Robin's Reef Light	40 39.4	74 03.6	
	Navy Yard, Flagstaff	40 42.0	73 58.5	Brooklyn.
	Castle Garden, Flagstaff	40 42.0	74 00.5	New York.
	Fire Island Light	40 37.9	73 12.8	
	Prince's Bay Light	40 30.4	74 12.5	

Digitized by Google

TABLE LIV.

Corrections and Additions.

	NAME OF PLACES.	Latitude. D. M.	Longitude. D. M.	REMARKS.
New Jersey.	Sandy Hook Light	40 27.7	73 59.8	
	Navesink Light	40 23.7	73 58.8	Southern Light.
	Ocean House Flagstaff	40 22.8	73 58.2	
	Barnegat Light	39 46.0	74 06.0	
	Tucker's Island Light	39 30.3	74 16.8	Little Egg Harbor Light.
	Cohansey Light	39 20.3	75 21.3	
	Egg Island Light	39 10.5	75 08.0	
	Cape May Light	38 55.8	74 57.3	
Penn.	PHILADELPHIA, State-House	39 56.9	75 08.7	
Delaware.	Wilmington Light	39 43.3	75 30.9	
	Bombay Hook Light	39 21.8	75 30.3	
	Mispilion Light	38 56.6	75 18.5	
	Breakwater Light	38 47.9	75 06.1	
	Cape Henlopen Light	38 46.6	75 04.7	
Maryland.	Susquehanna Light	39 32.4	76 04.8	
	Turkey Point Light	39 26.9	76 00.2	
	Baltimore, Washington Monument	39 17.8	76 36.6	
	Poole's Island Light	39 17.4	76 15.7	
	North Point Lower Light	39 11.6	76 26.2	
	North Point Upper Light	39 11.8	76 27.3	
	Bodkin Light	39 08.0	76 25.1	
	Annapolis, State-House	38 58.7	76 29.1	
	Sharp's Island Light	38 37.7	76 22.6	
	Clay Island Light	38 13.9	75 58.1	
	Point Lookout Light	38 02.3	76 19.0	
D. C.	National Observatory	38 53.6	77 02.8	Washington.
	WASHINGTON City, Dome of Cap.	38 53.3	77 00.2	
Virginia.	Fog Point Light	38 02.1	76 02.2	
	Assateague Light	37 54.6	75 21.1	
	Smith's Point Light	37 53.2	76 14.0	Mouth of Potomac.
	Watts' Island Light	37 46.9	75 53.3	
	New Point Comfort Light	37 18.0	76 16.4	
	Old Point Comfort Light	37 00.0	76 18.1	
	Smith's Island Light	37 07.8	75 52.2	
	Cape Charles	37 07.3	75 57.9	Trig. Point of C. S.
	Cape Henry Light	36 55.5	76 00.2	

Digitized by Google

TABLE LIV.

Corrections and Additions.

	NAME OF PLACES.	*Latitude.*	*Longitude.*	*REMARKS.*
		D. M.	D. M.	
N. C.	Kill Devil Hill	36 01.1	75 39.7	Trig. Point of C. S.
	Bodies' Island Light	35 47.3	75 31.6	
	New Inlet, South Point	35 41.1	75 28.5	Trig. Point of C. S.
	Cape Hatteras Light	35 15.2	75 30.9	
	Ocracoke Light	35 06.5	75 58.9	
S. C.	Fort Pinkney	32 46.4	79 54.4	Charleston.
	Charleston Light	32 41.9	79 52.5	
Geo.	SAVANNAH, Exchange	32 04.9	81 05.2	
Florida.	Cape Florida Light	25 39.9	80 05.0	
	Key West Light	24 33.0	81 47.3	
	Sand Key Light	24 27.2	81 51.9	
Alabama.	Mobile, Barton's Academy	30 41.4	88 01.9	
	Choctaw Point Light	30 40.2	88 01.1	
	Grant's Light	30 17.6	88 07.5	
	Mobile Point Light	30 13.8	88 00.5	
	Sand Island Light	30 11.3	88 02.0	
Mississippi.	Biloxi Light	30 23.8	88 53.1	
	Pass Christian Light	30 18.9	89 14.0	
	Round Island Light	30 17.5	88 34.1	
	Cat Island Light	30 13.9	89 08.7	
	Ship Island West	30 12.9	88 57.0	Trig. Point of C. S.
La.	Chandeleur Light	30 03.4	88 51.8	
Texas.	Galveston, Entrance	29 20.5	94 45.0	
	Galveston, Cathedral	29 18.3	94 47.0	
California.	Point Lobos	37 47.0	122 32.0	San Francisco Bay.
	South Farallon	37 41.6	122 59.2	
	Point Pinos	36 38.0		Monterey.
	Point Conception	34 26.9	120 25.7	
	Point Loma	32 40.2		San Diego Bay.

Digitized by Google

Stations on the Pacific Coast; determined astronomically by the U. S. Coast Survey.

STATIONS.	Latitude.	Longitude.
	° ′ ″	° ′ ″
San Diego	32 41 57·96 N.	117 13 25·00 W
San Nicolas	33 14 12·71	119 25 00·00
San Catalina	33 26 34·84	118 28 45·00
San Pedro	33 43 19·59	118 16 03·00
Prisoner's Harbor	34 01 10·20	119 40 00·00
Santa Barbara	34 24 24·71	119 40 18·00
Point Conception	34 26 56·30	120 25 39·00
San Luis Obispo	35 10 37·48	120 43 31·00
San Simeon	35 38 24·43	121 10 22·00
Point Pinos	36 37 59·86	121 54 25·00
Santa Cruz	36 57 26·93	122 00 10·00
Presidio Hill	37 47 36·15	122 26 15·00
Punta de los Reyes	37 59 34·20	122 57 40·10
Bodega Bay	38 18 20·37	123 02 28·80
Havens' Anchorage	38 47 57·87	123 34 00·70
Mendocino City	39 18 06·16	123 47 25·65
Shelter Cove	40 01 13·67	124 03 02·85
Bucksport	40 46 37·09	124 10 43·80
Trinidad Bay	41 03 20·04	124 08 07·95
Crescent City	41 44 44·10	124 11 13·95
Telegraph Hill	37 48 06·43	122 23 19·42
Cuyler's Harbor		120 20 27·00
San Clemente		118 34 00·00
Ewing Harbor	42 44 21·73	124 28 47·40
Umquah River	43 41 45·31	124 09 57·00
Cape Hancock	46 16 34·85	124 02 00·81
Point Hudson	48 07 03·02	122 44 33·00
False Dungeness	48 07 52·03	123 27 21·00
Scarborough Harbor	48 21 48·78	124 37 12·00
Lummie Island	48 44 01·74	122 40 37·35
Astor Point	46 11 27·61	123 49 31·65
Heard's Islands, a new discovery, from	53 03	73 30 E.
Heard's Islands, a new discovery, to	53 00	72 30

Positions of points in the North Pacific Ocean, prepared by Lieut. Bent, by direction of Commodore Perry, commander of the late expedition to Japan.

NAMES OF PLACES.	Latitude.	Longitude.
	° ′ ″	° ′ ″
FORMOSA.—S. E. point	21 56 00 N.	120 56 00 E.
ISLANDS, &c.—Vele Rete Rocks	21 42 00	120 49 00
Agenhue	26 32 00	127 12 00
Lew Chew, Napha	26 12 00	127 43 00
" " N. Pt. Cape Hope	26 48 00	128 16 00
Borodino, Northern Island	25 52 00	131 13 00
" Southern Island	25 48 00	131 12 00
Disappointment or Rosario Island	27 14 00	140 57 00
Bonin Islands, Port Lloyd	27 05 00	142 15 00
Ponafidin or St. Peters	30 35 00	140 20 00
Lot's Wife (high rock)	29 47 00	140 22 30
Redfield Rocks, Northern	33 57 31	138 49 13
" " Southern	33 56 13	138 48 31
Broughton Rocks	33 43 00	139 17 00
Rock Island	34 34 20	138 57 10
JAPAN ISLANDS.—NIPHON, Cape Idzou	34 36 03	138 50 35
Simoda (Centre Island)	34 39 49	138 57 30
Cape Sagami	35 06 30	139 42 45
Webster Island, Yedo Bay	35 18 30	139 40 34
Treaty Building, Yoku-hama	35 27 15	139 40 23
Cape Susaki	34 55 00	139 47 00
Siriji Saki, Northern point	41 23 00	141 30 00
YESO.......Cape Blunt, Sangar Straits	41 44 00	141 03 00
Hakodadi, Kamida Creek	41 49 00	140 47 45

Digitized by Google

TABLE LIV.

Corrections and Additions.

	NAME OF PLACES.	Latitude. D. M.	Longitude. D. M.	REMARKS.
N. C.	Kill Devil Hill	36 01.1	75 39.7	Trig. Point of C. S.
	Bodies' Island Light	35 47.3	75 31.6	
	New Inlet, South Point	35 41.1	75 28.5	Trig. Point of C. S.
	Cape Hatteras Light	35 15.2	75 30.9	
	Ocracoke Light	35 06.5	75 58.9	
S. C.	Fort Pinkney	32 46.4	79 54.4	Charleston.
	Charleston Light	32 41.9	79 52.5	
Geo.	SAVANNAH, Exchange	32 04.9	81 05.2	
Florida.	Cape Florida Light	25 39.9	80 05.0	
	Key West Light	24 33.0	81 47.3	
	Sand Key Light	24 27.2	81 51.9	
Alabama.	Mobile, Barton's Academy	30 41.4	88 01.9	
	Choctaw Point Light	30 40.2	88 01.1	
	Grant's Light	30 17.6	88 07.5	
	Mobile Point Light	30 13.8	88 00.5	
	Sand Island Light	30 11.3	88 02.0	
Mississippi.	Biloxi Light	30 23.8	88 53.1	
	Pass Christian Light	30 18.9	89 14.0	
	Round Island Light	30 17.5	88 34.1	
	Cat Island Light	30 13.9	89 08.7	
	Ship Island West	30 12.9	88 57.0	Trig. Point of C. S.
La.	Chandeleur Light	30 03.4	88 51.8	
Texas.	Galveston, Entrance	29 20.5	94 45.0	
	Galveston, Cathedral	29 18.3	94 47.0	
California.	Point Lobos	37 47.0	122 32.0	San Francisco Bay.
	South Farallon	37 41.6	122 59.2	
	Point Pinos	36 38.0		Monterey.
	Point Conception	34 26.9	120 25.7	
	Point Loma	32 40.2		San Diego Bay.

Digitized by Google

Stations on the Pacific Coast; determined astronomically by the U. S. Coast Survey.

STATIONS.	Latitude.	Longitude.
	° ′ ″	° ′ ″
San Diego	32 41 57·96 N.	117 13 25·00 W
San Nicolas	33 14 12·71	119 25 00·00
San Catalina	33 26 34·84	118 28 45·00
San Pedro	33 43 19·59	118 16 03·00
Prisoner's Harbor	34 01 10·20	119 40 00·00
Santa Barbara	34 24 24·71	119 40 18·00
Point Conception	34 26 56·30	120 25 39·00
San Luis Obispo	35 10 37·48	120 43 31·00
San Simeon	35 38 24·43	121 10 22·00
Point Pinos	36 37 59·86	121 54 25·00
Santa Cruz	36 57 26·93	122 00 10·00
Presidio Hill	37 47 36·15	122 26 15·00
Punta de los Reyes	37 59 34·20	122 57 40·10
Bodega Bay	38 18 20·37	123 02 28·80
Havens' Anchorage	38 47 57·87	123 34 00·70
Mendocino City	39 18 06·16	123 47 25·65
Shelter Cove	40 01 13·67	124 03 02·85
Bucksport	40 46 37·09	124 10 43·80
Trinidad Bay	41 03 20·04	124 08 07·95
Crescent City	41 44 44·10	124 11 13·95
Telegraph Hill	37 48 06·43	122 23 19·42
Cuyler's Harbor		120 20 27·00
San Clemente		118 34 00·00
Ewing Harbor	42 44 21·73	124 28 47·40
Umquah River	43 41 45·31	124 09 57·00
Cape Hancock	46 16 34·85	124 02 00·81
Point Hudson	48 07 03·02	122 44 33·00
False Dungeness	48 07 52·03	123 27 21·00
Scarborough Harbor	48 21 48·78	124 37 12·00
Lummie Island	48 44 01·74	122 40 37·35
Astor Point	46 11 27·61	123 49 31·65
Heard's Islands, a new discovery, from	53 03	73 30 E.
Heard's Islands, a new discovery, to	53 00	72 30

Positions of points in the North Pacific Ocean, prepared by Lieut. Bent, by direction of Commodore Perry, commander of the late expedition to Japan.

NAMES OF PLACES.	Latitude.	Longitude.
	° ′ ″	° ′ ″
FORMOSA.—S. E. point	21 56 00 N.	120 56 00 E.
ISLANDS, &c.—Vele Rete Rocks	21 42 00	120 49 00
Agenhue	26 32 00	127 12 00
Lew Chew, Napha	26 12 00	127 43 00
" " N. Pt. Cape Hope	26 48 00	128 16 00
Borodino, Northern Island	25 52 00	131 13 00
" Southern Island	25 48 00	131 12 00
Disappointment or Rosario Island	27 14 00	140 57 00
Bonin Islands, Port Lloyd	27 05 00	142 15 00
Ponafidin or St. Peters	30 35 00	140 20 00
Lot's Wife (high rock)	29 47 00	140 22 30
Redfield Rocks, Northern	33 57 31	138 49 13
" " Southern	33 56 13	138 48 31
Broughton Rocks	33 43 00	139 17 00
Rock Island	34 34 20	138 57 10
JAPAN ISLANDS.—NIPHON, Cape Idzou	34 36 03	138 50 35
Simoda (Centre Island)	34 39 49	138 57 30
Cape Sagami	35 06 30	139 42 45
Webster Island, Yedo Bay	35 18 30	139 40 34
Treaty Building, Yoku-hama	35 27 15	139 40 23
Cape Susaki	34 55 00	139 47 00
Siriji Saki, Northern point	41 23 00	141 30 00
YESO.......Cape Blunt, Sangar Straits	41 44 00	141 03 00
Hakodadi, Kamida Creek	41 49 00	140 47 45

Digitized by Google

GULF STREAM.

UNDER the direction of Dr. Bache, the Superintendent of the Coast Survey, the exploration of the Gulf Stream, extending from about 42° N. latitude to about 28½°, and from about 65½° to 80½° W. longitude, has been made—and from his notes on the same, we have extracted the following:—

The ocean within the region of the Gulf Stream is divided into several bands of higher and lower temperature, of which the *axis of the Gulf Stream* is the hottest, the temperature falling rapidly inshore and more slowly outside.

Thus, on a line perpendicular to the axis of the stream, drawn from Sandy Hook, the temperature at the depth of 15 fathoms and 100 miles, was 63°; at 150 miles, 67°; at 240 miles, 63½°; 280 miles, 80½°.

The late Lieut. G. M. Bache discovered a band of water so much colder than the rest that he called it the "*Cold Wall,*" the cold water appearing to confine the hot water as by a wall on the *inshore side.* Its distance from Sandy Hook is from 230 to 280 miles; its distance from Cape May is between 132 and 178 miles: the thermometer at 15 fathoms on the Sandy Hook section rising from 62½° to 80½°, or 18° in 50 miles; on the Cape May section rising from 62° to 83½°, or 21½° in 46 miles: at Charleston, at the depth of 20 fathoms, rising from 67½° to 79° in 15 miles, and at St. Simons from 70° to 76° in 12 miles, being at the rate of 4½ tenths to 9 tenths of a degree to a mile. Besides this remarkable cold band there are *two outside* ones, sufficiently well defined, though the differences of temperature are less marked, the existence of which should be known to the navigator, that he be not perplexed in crossing the stream and finding warm water, to meet with cold, then warm and then cold again. The positions of these bands may be somewhat changed, when more thoroughly considered. *Inside* of the "Cold Wall" there is a *warm band* and then the cold water of the shore. The axis of the stream takes, in general, the curve of the coast, below rather than above the water, being turned to the eastward by the shoals off the southern coast of New England. The

Digitized by Google

axis of *the cold band*, the minimum of temperature which forms the "Cold Wall," follows the shore and shoals in its bendings more closely than the axis of the Gulf Stream; and is traced with considerable probability to longitude 66°. The warm water of the Gulf Stream rests on a cold current flowing towards Cape Florida, the coldest water keeping near the Atlantic coast, below the surface if not at it. By observations at several points along the coast in 400 fathoms, between Sandy Hook and Cape Florida, the surface temperature exceeding 80°, the thermometer indicated 46½° to 55°; off Hatteras, in 1000 fathoms, 40°.

The warm water of the Gulf Stream is of very different depths at different points of its course, and in different parts of any one of the sections across it. From the deepest portion in the cross sections the warmer water flows off towards the shore, and outwards, overlying the cold. This thins out as it approaches the shore, the cold water which lies at the bottom coming up in the northern sections, but the warm water prevailing to the very shore and at considerable depths in the southern. When the cold water is forced up by a bank or shoal, or when it comes to the surface from the thinning out of the warm, there is of course a considerable change of temperature. This cold water from the north prevails on the inside of the cold axis, at moderate depths, as far south as Hatteras, and probably to the south of it. Acting Master Jones found it, 50 miles S. E. of Charleston light, running to the S. W., the surface water being 75°, and at 20 fathoms 68°, the axis of the Gulf Stream being 82°, moderately warm water extending to the bottom.

The direction of the axis of the stream indicates the set of the current in that band. To the right and left of it, the current is outward and onward, and to the left as far as the Cold Wall is inward and onward. Inside of the *Cold Wall*, north of Cape Hatteras, and probably south of it, the current is southerly, along the coast.

The velocity of the current in the axis of the stream, on the Cape Canaveral section, is about 3 miles per hour; on the Cape Fear section, about 2 miles per hour, and on the Sandy Hook section, about 1 mile per hour.

In the Charleston section, and to the south, the bands of cold and warm water, with scarcely an exception, are *produced by the shape of the bottom*. The elevated portions of the bottom, forcing up the cold water into the warm, cause cold streaks, and the division into cold and warm bands.

The variations in temperature in different years and at different seasons is considerable, the more southerly sections in the same season giving usually

Digitized by Google

the highest temperature. But in July, 1846, on the axis of the Gulf Stream, the temperature was higher at Sandy Hook than in June, 1853, at Canaveral, by 1½°, and higher than at Charleston by 5½°.

The low temperatures observed, show that the Gulf Stream is comparatively a superficial current on the surface of an ocean of cold water. The temperatures have been observed from the surface to the depth of 500 fathoms—in a few instances as low as 13 to 1500 fathoms.

Navigators are advised to make their observations at the depth of 20 fathoms. Saxton's metallic thermometer is highly recommended. A common Six's self-registering thermometer, or a common thermometer enveloped in cotton or other bad conducting material, allowed to remain below the surface long enough to take the temperature, will answer.

Mr. George W. Blunt in his "Atlantic Memoir" remarks—

That in summer the temperature of the Gulf water, south of Hatteras, is about the same as the water on soundings. In the months of July and August, 1845, the temperature of the water, from the Mississippi to Cape Hatteras, both in and out of the stream, even to the very mouth of the Atlantic rivers, was 84° to 82°.

The current on the *western* edge of the Gulf Stream, from Sandy Hook to Cape Hatteras, sets south, a little westerly, about 20 miles in 24 hours.

The current on the *eastern* edge of the Gulf Stream, nearly down to Matanilla Reef, sets to the south and west, almost opposite to the flow of the Gulf, at an average of 20 miles in 24 hours.

For further information respecting the Gulf Stream, the navigator is referred to Dr Bache's "Notes" on the same, in Blunt's Coast Pilot, and the "Memoir on the dangers and ice in the North Atlantic Ocean," by G. W. Blunt.

Digitized by Google

PREFACE.

In the Preface to the first edition of this work, it was observed, that the object of the publication was to collect into one volume all the rules, examples, and tables, necessary for forming a complete system of *practical* navigation. To do this, those authors were consulted whose writings afforded the best materials for the purpose; and such additions and improvements were introduced as were suggested by a close attention to the subject; and the accuracy of the tables accompanying the work was ensured by actually going through all the calculations necessary to a complete examination of them, making the last figure exact to the nearest unit. In performing this, above eight thousand errors were discovered and corrected in Moore's Practical Navigator, and above two thousand in the second edition of Maskelyne's Requisite Tables. Almost all the errors in Maskelyne's collection were in the last decimal place, and in most cases would but little affect the result of any *nautical* calculation; but when it is considered that most of those tables are useful in *other* calculations, where great accuracy is required, it will not be deemed an unnecessary improvement to have corrected so great a number of small errors.

Several articles were added in the second edition, particularly the description and use of the circular instrument of reflection, methods of surveying harbors, new tables, &c. In the third, and subsequent editions, several improvements were made, and an Appendix was given, containing methods of projecting and calculating eclipses of the moon and sun, and occultations of the fixed stars or planets by the moon; rules for deducing the longitude of a place from observations of eclipses of the sun or occultations; a new and short method of calculating the altitude and longitude of the nonagesimal degree of the ecliptic; solutions of several useful problems of nautical astronomy, and an improvement of Napier's rules for the solution of spheric triangles. Several new tables were added. The table of latitudes and longitudes was much increased and corrected.

A new article was given in the sixth and seventh editions, on the method of finding the latitudes by two altitudes of the same or of different objects, being

Digitized by Google

an improvement of Mr. Ivory's solution. The method we have given is direct and simple, embracing all the cases of the problem; a point which is not sufficiently attended to in some works of celebrity. This article is an important addition to the work, and it is recommended to the consideration of navigators.

The tables, published separately in the Appendix of the first edition, are introduced into the body of this work, and are extended so as to render the use of them more simple. The first method of working a lunar observation, published in that Appendix, which has one great advantage over all other approximate methods, in the manner of applying the corrections, (all of them being additive,) is here explained and illustrated by several examples. The second is an improvement of Lyons's method, which had been known for many years, but had not been generally used, because the tables were not sufficiently extended. This difficulty is now obviated, by means of Tables XLVII. XLVIII., which have been compared with Thompson's tables, and many of them recomputed by the aid of Shephard's tables. The third method was given by the author of this work. in 1795. The fourth method is an improvement of Witchell's process, in which, without altering materially the calculation, the number of cases is considerably reduced.

Any person who wishes to examine the tables, may do it by the methods used for that purpose, which will here be explained, with some additional remarks:

Tables I. and II. were calculated by the natural sines taken from the fourth edition of Sherwin's logarithms, which were previously examined. by differences; when the proof-sheets of the first edition were examined, the numbers were again calculated by the natural sines in the second edition of Hutton's logarithms; and if any difference was found, the numbers were calculated a third time by Taylor's logarithms.

Table III. contains the meridional parts for every degree and minute of the quadrant, calculated by the following rule, viz.

$$M = T \times 0.0007915704468,$$

in which T is the log. tangent less radius of half the latitude, increased by 45°, taken to seven places of figures, reckoned as integers; and M is the meridional parts of that latitude in miles.

Table IV. contains the declination of the sun, which was compared with the Nautical Almanacs for the years *1833, 1834, 1835, and 1836, and marked to the nearest minute.

Table IV. A. The equation of time, for the years *1833, 1834, 1835, and 1836.

Table V. contains the correction of the sun's declination, as published by Dr. Maskelyne. The correction taken from this table will rarely differ more than sixteen or seventeen seconds from the truth.

* Altered to correspond to the years 1848, 1849, 1850, and 1851.

Digitized by Google

Table VI. contains the mean of the sun's right ascension, taken from the Nautical Almanacs for the years 1833, 1834, 1835, and 1836.

Table VI. A. contains the correction for the daily variation of the equation of time

Table VII. contains the amplitudes of the sun for various latitudes and declinations, calculated by Taylor's logarithms, by this rule:

Log. sec. lat. + log. sine declination — 10.0000000 = log. sine amplitude.

Table VIII. contains the right ascensions and declinations of one hundred and eighty stars of the first, second, and third magnitudes, with their annual variations, adapted to the beginning of the year 1830. This table was abridged from that published by the astronomer royal at Greenwich, (Mr. Pond,) in the year 1833.

Table IX. contains the time of the sun's rising and setting, calculated by Taylor's logarithms, by this rule:

Log. cos. hour = log. tang. declin. + log. tang. latitude — 10.0000000.

Table X. contains the distances at which any object is visible at sea. calculated by the rule given in § 195 of Vince's Astronomy, in which the terrestrial refraction is noticed. This circumstance was neglected by Robertson Moore, and others, and of course their tables are erroneous. The rule given by Mr. Vince, expressed in logarithms, is this:

0.12155 + half log. of height in feet = log. of dist. in statute miles.

In reducing the rule to logarithms, the radius of the earth was called 20911790 feet, which agrees nearly with the mean value given in De La Lande's Astronomy.

Table XI. is a common table of proportional parts, the construction of which does not need any explanation.

Table XII. contains the refraction of the heavenly bodies, calculated by Dr. Bradley's rule, supposing the refraction to be as the tangent of the apparent zenith distance of the object, decreased by three times the refraction, the horizontal refraction being supposed equal to 33′. The rule, expressed in logarithms, is this:

Log. tang. (app. zen. dist.—3. refraction) — 8.2438534 = log. of ref. in sec.

The numbers calculated by this rule agree nearly with those published in Table 1 of Maskelyne's Requisite Tables.

Table XIII. contains the dip of the horizon for various heights, calculated by the rule in § 197 of Vince's Astronomy, in which the terrestrial refraction is allowed for. All the numbers of this table differ a little from those published by Dr. Maskelyne, who had made a different allowance for that refraction. The rule given by Mr. Vince, expressed in logarithms, is,

1.7712711 + half the log. of the height in feet = log. dip in seconds.

Table XIV. contains the sun's parallax in altitude, calculated by multiplying

Digitized by Google

the natural sine of the apparent zenith distance by the sun's horizontal parallax $8\frac{3}{4}''$. The numbers in this table agree with those published by Dr. Maskelyne.

Table XV. contains the

Augmentation of the moon's semi-diameter $= 15''.626 \times$ sine ☽'s altitude. This table agrees nearly with that published by Maskelyne.

Table XVI. contains the dip for various distances and heights, calculated by this rule,

$$D = \frac{3}{7} d + 0.56514 \times \frac{h}{d},$$

in which D represents the dip in miles or minutes, d the distance of the land in sea miles, and h the height of the eye of the observer in feet.

Tables XVII., XVIII., and XIX., were first calculated by the author of this work, and published in the Appendix to the first edition. The correction in the first of these tables is equal to the difference between the star's refraction and 60′. The correction of Table XVIII. is equal to the difference between 60 and the correction of the sun's altitude for parallax and refraction. The correction of Table XIX. is equal to the difference between 59′ 42″ and the correction of the moon's altitude for parallax and refraction. The logarithms in each of these tables may be found by adding together the constant log. 9.6990, the log. cosine of the apparent altitude of the object, the proportional logarithm of the correction of the altitude of the object for parallax and refraction, and rejecting 20 from the index. The methods of performing these calculations are so obvious, that it is unnecessary to enter into any further explanation. Most of the numbers in these tables were calculated three different times.

Table XX. Corrections in seconds, *additive*. This was computed by means of Shephard's tables.

Table XXI., for turning time into degrees, is the same as in other works of this kind.

Table XXII. contains the proportional logarithms for three hours. The numbers of this table may be found by subtracting the logarithm of the time in seconds from the log. of 10800″, or, which is the same thing, by the following rule:

$$\text{Prop. log. } T = 4.0334738 - \text{log. of } T \text{ in seconds},$$

neglecting the three right-hand figures of the remainder.

Table XXIII. was first constructed by Mr. Douwes of Amsterdam, about the year 1740, for which he received £50 of the commissioners of longitude in England. This table was published in the first and second editions of the Requisite Tables; in the former of which it was carried as far as 6 hours; in the latter, the table of log. rising was extended to 9 hours; in the present edition of this work it is extended to 12 hours. The numbers in this table are

Digitized by Google

easily deduced from the log. sines, log. cosecants, and log. versed sines of the hour to which they correspond. Thus if the time, opposite to any number in these tables, turned into degrees, is H, we shall have

$$\text{Log. } \tfrac{1}{2} \text{ elapsed time of } H = \text{log. cosecant } H - 10.0000000.$$

$$\text{Log. middle time} = \text{log. sine } H - 4.6989700.$$

$$\text{Log. rising } H \begin{cases} = \text{log. versed sine } H - 5.0000000. \\ = 2 \times \text{log. sine } \tfrac{1}{2} H - 14.6989700. \end{cases}$$

By means of these formulas, the numbers of Table XXIII. were calculated by Sherwin's, Hutton's, and Taylor's logarithms, and above a thousand errors were discovered in the second edition of the Requisite Tables, most of which were in the additional three hours (from six to nine hours) not published in the first edition. About two thirds of these additional numbers differ from their true values by one or two units.

Table XXIV. was compared with Sherwin's and Hutton's tables, and a few errors corrected.

Table XXV. contains the log. sines, log. tangents, &c. corresponding to points and quarter points of the compass. This was compared with Sherwin's, Hutton's, and Taylor's logarithms.

Table XXVI., containing the common logarithms of numbers, was compared with Sherwin's, Hutton's, and Taylor's logarithms.

Table XXVII. contains the common log. sines, tangents, secants, &c. This was compared with Sherwin's, Hutton's, and Taylor's tables. Two additional columns are given in this table, which are very convenient in finding the time from an altitude of the sun; also, three columns of proportional parts for seconds of space; and a small table at the bottom of each page, for finding the proportional parts for seconds of time. The degrees are marked to 180°, which saves the trouble of subtracting the given angle from 180° when it exceeds 90°.

Table XXVIII. was calculated by proportioning the daily variation of the time of the moon's passing the meridian.

Table XXIX. contains the correction of the moon's altitude for parallax and refraction, corresponding to the parallax 57′ 30″.

Tables XXX. and XXXI. are tables of proportional parts, taken from the Requisite Tables, with a few corrections.

Table XXXII. contains the variation of the altitude of any heavenly body, for one minute of time from noon, for various degrees of latitude and declination. The following method was used in constructing the table: A and B were calculated for each degree of declination by these formulas;

$$\text{Log. } A = \text{log. } 1''.96349 + 2 \text{ log. cos. declination} - 20.00000,$$

$$\text{Log. } B = \text{log. } A + \text{log. tang. declination} - 10.00000;$$

and then the correction of the table corresponding to the zenith distance

Digitized by Google

Z (= lat. $\frac{+}{\infty}$ dec.) was found by this formula: A × cotang. Z ± B. To facilitate the computation of these numbers, a table of the products of A by the whole numbers from 1 to 9 was calculated.

Table XXXIII. contains the squares of the minutes and parts of a minute of time corresponding to every second from 0^s to 12^m 59^s. This requires no explanation.

Table XXXIV. contains the error of an observed angle arising from a deviation of 1′ in the parallelism of the surfaces of the central mirror, those surfaces being supposed to be perpendicular to the plane of the instrument. The correction in the fifth column of this table corresponding to any angle A in the first column, may be found nearly by Hutton's logarithms, as follows: To the constant logarithm 0.07345 add the log. secant of ½ A; find this in the column of log. tangents, and take out the corresponding natural secant B; then the correction will be 2′ (B — 1.55.) The numbers in the second column are nearly equal to those in the fifth corresponding to the angle A + 20°, decreased by 1″.68. The numbers in the third column are equal to the difference between 1″.68, and the numbers in the fifth corresponding to A ∾ 20°. The numbers in the fourth column are equal to the half-difference of the numbers on the same horizontal line in columns second and third, when it exceeds 40°, otherwise their half-sum.

Table XXXV. contains the correction to be applied to an observation taken in a direction inclined to a plane of the instrument. The following rule was used in calculating this table: Find an arc A such that

Log. sine A = log. sine ½ observed angle + log. cosine of error of inclination.

Then the difference between 2 A and the observed angle will be the tabular correction.

Table XXXVI. contains the variation of the mean refraction (given in Table XII.) for various temperatures and densities of the air. The correction given in this table is nearly the same as that deduced from Dr. Bradley's rule, which is as follows: As the mean height of the barometer, 29.6 inches, is to the true height, so is the mean refraction to the corrected refraction; and as 350, increased by the height of Fahrenheit's thermometer, is to 400, so is the corrected to the true refraction.

Table XXXVII. contains the latitudes and longitudes of the fixed stars of the 1st, 2d, and 3d magnitudes. The nine stars from which the distances are marked in the Nautical Almanac, are given from the table published in the Nautical Almanac for 1820, allowing for 10 years' annual variation, to reduce them to 1830. The rest were deduced from the table published in the second edition of Dr. Mackay's treatise on longitude, supposing the annual precession 50″.35, and the secular equation as in his table.

Table XXXVIII. was calculated by this rule: Suppose L to be the lati-

Digitized by Google

tude, R he reduction of latitude; then log. cotang $(L - R) = 0.0029001 +$ log. cotang. L. The reduction of parallax corresponding to $53'$, $57'$, and $61'$, was found by the formulas respectively,

$$5''.3 - 5''.3 \cos. 2L; \quad 5''.7 - 5''.7 \cos. 2L; \quad 6''.1 - 6''.1 \cos. 2L.$$

Table XXXIX. was calculated by the rule in Vol. I., page 334, of Vince's Astronomy, supposing S to be the place of the sun, P that of the planet, and T that of the earth:

$$\text{Aberration} = -20''. \cos. STP - 20'' \sqrt{\frac{ST}{SP}} \cos. SPT,$$

making use of the distances, &c. given by La Place in Vol III. of his Mécanique Céleste. A small alteration was made in the rule in calculating the aberration of Mercury.

Table XL. was calculated by $-17''.9$ sine long. ☽'s node.

Table XLI. was calculated by $-20''$. cos. argument.

Table XLII. Part I. $= -19''.173$ cos. arg.
Part II. $= 0''.827$ cos. arg.
Part III. $= -3''.9814$ cos. arg.

Table XLIII. Part I. $= -8''.33$ cos. arg.
Part II. $= -1''.22$ cos. arg.
Part III. $= -16''.382$ sine arg.

Table XLIV. Part I. $= 8''.1845$ sine arg.

Part II. $= \dfrac{(\text{arg. in seconds})^2}{960''}$

Part III. $= 960'' \times$ sine ☽'s par. in lat. $\times$ tang. ☽'s true lat. $- 960'' \times$ versed sine par. in lat.

If we suppose the sum of these three parts to be S seconds, and the moon's horizontal semi-diameter to be D minutes,

Part IV. corresponding to S and D, will be $S \times \dfrac{(D+16)(D-16)}{256}$.

Table XLV. The arguments at the side being B and $12 - B$ hours, and the second difference at the top A, the correction of this table will be $A \times \dfrac{B.(12-B)}{288}$.

Table XLVI. gives the variation of the altitude of any heavenly body, arising from a change of 100 seconds in the declination.

Table XLVII. contains the proportional logarithms as in Table XXII., increasing the argument at the bottom of the table by 5°, and inverting the order of the numbers.

Table XLVIII. contains the third correction of a lunar observation in Lyons's improved method. These numbers may be easily computed from Shephard's tables, using the moon's parallax 57′ 30″, which is nearly its mean value.

Digitized by Google

Table XLIX. For computing the parallax in altitude of a planet, supposing its horizontal parallax to be 35″.

Table L. Proportional parts, to reduce the numbers of Table XLIX. to the values corresponding to the actual horizontal parallax of a planet.

Table LI. To change mean solar time into sideral time.

Table LII To change sideral time into mean solar time.

Table LIII. Variation of the compass in different parts of the world, deduced from Barlow's chart.

Table LIV. contains the latitudes and longitudes of the most remarkable ports, harbors, &c. in the world, from the latest and best authorities.

Table LV. contains the times of high water on the full and change of the moon, with the vertical rise of the tide, at many ports, harbors, &c. in the world. This table, (like the preceding,) depending wholly on observations, is therefore liable to be erroneous, though great pains have been taken to make it as correct as possible, using for this purpose the observations collected by Dr. Whewell.

Table LVI. Extracts from the Nautical Almanac for the year 1836, corresponding to the examples which are given in this work.

The tables have all been newly cast from a clear and beautiful type, and above ninety pages have been added to the collection. Various improvements have been made in the body of the work, which is now for the first time completely stereotyped. Among the additions made to the work, may be mentioned the description of a portable transit instrument, with its uses in regulating a chronometer, and in finding the longitude by observations of the moon's transits over the meridian of the place of observation; methods for making allowance for any observed change in the rate of a chronometer; new methods and improvements in the computation of lunar observations, &c.

In preparing this edition, I have been very much assisted by my son, J. Ingersoll Bowditch, who computed most of the new tables, and carefully examined those which were taken from other works. By associating him with me, many improvements have been made which otherwise would not have been introduced.

N. BOWDITCH.

Boston, October 1, 1837.

Digitized by Google

CONTENTS.

Digitized by Google

Digitized by Google

Digitized by Google

ARRANGEMENT OF THE TABLES.

Digitized by Google

APPENDIX.

Digitized by Google

INDEX TO TABLE LIV.

LATITUDES AND LONGITUDES.

Digitized by Google

Digitized by Google

Digitized by Google

SIGNS AND ABBREVIATIONS

USED IN THIS WORK.

+ is the sign of *addition*, and denotes that whatever number or quantity follows the sign, must be added to those that go before it; thus, $9 + 8$ signifies that 8 is to be added to 9; or $A + B$ implies that the quantities represented by A and B are to be added together. The sign + is called the *positive* sign.

- the sign of *subtraction*, and denotes that the number following it must be subtracted from those going before it; thus, $7 - 5$ signifies that 5 must be subtracted from 7 The sign — is called the *negative* sign.

× is the sign of *multiplication*, and shows that the numbers placed before and after it are to be multiplied together; thus, 7×9 signifies 7 multiplied by 9, which makes 63; and $7 \times 8 \times 2$ signifies the continued product of 7 by 8 and by 2, which makes 112. Multiplication is also denoted by placing a point between the quantities to be multiplied together; thus, $A \cdot B$ signifies that A is to be multiplied by B.

÷ is the sign of *division*, and signifies that the number that stands before it is to be divided by the number following it; as, $72 \div 12$ shows that 72 is to be divided by 12 Division may also be denoted by placing two points between the numbers; thus, $72 : 12$ represents 72 divided by 12; or by placing the numbers thus, $\frac{72}{12}$, which signifies 72 divided by 12.

() or $\overline{\quad}$. Either of these marks is used for connecting numbers together; thus, $\overline{3 + 4} \times 6$, or $(3 + 4) \times 6$, signifies that the sum of 3 and 4 is to be multiplied by 6

= is the sign of *equality*, and shows that the numbers or quantities placed before it are equal to those following it; thus, $8 \times 12 = 96$; or, 8 multiplied by 12 are equal to 96 and $\overline{7 + 2} \times 4 = 36$.

:: are the signs of *proportion*, and are used thus; $7 : 14 :: 10 : 20$, that is, as 7 is to 14, so is 10 to 20; or, $A : B :: C : D$, that is, as A is to B, so is C to D.

° signifies *degrees;* thus, 45° represents 45 degrees.

′ signifies *minutes;* thus, 24′, or 24 minutes.

″ signifies *seconds;* thus, 44″, or 44 seconds.

‴ signifies *thirds*, or sixtieth parts of seconds; thus, 44‴, or 44 thirds.

In noting any time, *d* is the mark for *days*, *h* for *hours*, *m* for *minutes*, &c.

S. signifies *sine*. N. S. signifies *natural sine*.

Sec. signifies *secant*.

Tan. signifies *tangent*.

Cosine, Cotangent, or Cosecant of an arc, signifies the sine, tangent, or secant of the complement of that arc respectively.

∠ signifies *angle*.

△ signifies *triangle*. △'s, *triangles*.

□ signifies a *square*.

☉ or ☉, *the sun*. ○ or ☽, *the moon*. ✱ *a star*. L. L. *lower limb*. U. L. *upper limb*. N. L. *nearest limb*. S. D. *semi-diameter*. P. L. *proportional logarithm*. N. A. *Nautical Almanac*. Z. D. *zenith distance*. D. R. *dead reckoning*.

DIRECTIONS FOR THE BINDER.

Plate I. to front the title-page.
II. to front page 17.
III. to front page 48.
IV. to front page 50.
V. to front page 52.
VI. to front page 54.
VII. to front page 112.
Plate VIII. to front page 116.
IX. to front page 120.
X. to front page 136.
XI. to front page 144.
XII. to front page 152.
XIII. to front page 156.
XIV. to front page 481, Appendix.

Digitized by Google

DECIMAL ARITHMETIC.

Many persons who have acquired considerable skill in common arithmetic, are unacquainted with the method of calculating by decimals, which is of great use in Navigation; for which reason it was thought proper to prefix the following brief explanation.

Fractions, or *Vulgar Fractions*, are expressions for any assignable part of a unit; they are usually denoted by two numbers, placed the one above the other, with a line between them; thus $\frac{1}{4}$ denotes the fraction one fourth, or one part out of four of some whole quantity, considered as divisible into four equal parts. The lower number, 4, is called the *denominator* of the fraction, showing into how many parts the whole or integer is divided; and the upper number, 1, is called the *numerator*, and shows how many of those equal parts are contained in the fraction. And it is evident that if the numerator and denominator be varied in the same ratio, the value of the fraction will remain unaltered; thus, if the numerator and denominator of the fraction, $\frac{1}{4}$, be multiplied by 2, 3, or 4, &c., the fractions arising will be $\frac{2}{8}$, $\frac{3}{12}$, $\frac{4}{16}$, &c., which are evidently equal to $\frac{1}{4}$.

A *Decimal Fraction* is a fraction whose denominator is always a unit with some number of ciphers annexed, and the numerator any number whatever; as, $\frac{2}{10}$, $\frac{3}{100}$, $\frac{16}{1000}$, &c. And as the denominator of a decimal is always one of the numbers 10, 100, 1000, &c., the inconvenience of writing the denominator may be avoided, by placing a point between the integral and the fractional part of the number; thus, $\frac{3}{10}$ is written .3; and $\frac{14}{100}$ is written .14; the *mixed* number $3\frac{14}{100}$, consisting of a whole number and a fractional one, is written 3.14.

In setting down a decimal fraction, the numerator must consist of as many places as there are ciphers in the denominator; and if it has not so many figures, the defect must be supplied by placing ciphers before it; thus, $\frac{16}{100} = .16$, $\frac{16}{1000} = .016$, $\frac{16}{10000} = .0016$, &c. And as ciphers on the right hand side of integers increase their value in a tenfold proportion, as, 2, 20, 200, &c., so, when set on the left hand of decimal fractions, they decrease their value in a tenfold proportion, as, .2, .02, .002, &c.; but ciphers set on the right hand of these fractions make no alteration in their value, neither of increase or decrease; thus, .2 is the same as .20 or .200. The common arithmetical operations are performed the same way in decimals as they are in integers; regard being had only to the particular notation, to distinguish the integral from the fractional part of a sum.

ADDITION OF DECIMALS.

Addition of decimals is performed exactly like that of whole numbers, placing the numbers of the same denomination under each other, in which case the decimal separating points will range straight in one column.

EXAMPLES.

	Miles.	Feet.	Inches.
	26.7	1.26	272.3267
	32.15	2.31	.0134
	143.206	1.785	2.1576
	.003	2.0	31.4
Sum	202.059	7.355	305.8977

Digitized by Google

SUBTRACTION OF DECIMALS.

Subtraction of decimals is performed in the same manner as in whole numbers, by observing to set the figures of the same denomination and the separating points directly under each other.

EXAMPLES.

From	31.267	36.75	1.254	1364.2
Take	2.63	.026	.316	25.163
Difference	28.637	36.724	.938	1339.037

MULTIPLICATION OF DECIMALS.

Multiply the numbers together the same as if they were whole numbers, and point off as many decimals from the right hand as there are decimals in both factors together and when it happens that there are not so many figures in the product as there must be decimals, then prefix as many ciphers to the left hand as will supply the defect

EXAMPLE I.

Multiply 3.25 by 4.5.

```
        3.25
        4.5
       -----
        1.625
       13.00
       -----
Answer 14.625
```

In one of the factors is one decimal, and in the other two; their sum, 3, is the number of decimals of the product.

EXAMPLE II.

Multiply 0.5 by 0.7.

```
        0.5
        0.7
       ----
Answer  0.35
```

EXAMPLE III.

Multiply 3.25 by .05.

```
        3.25
         .05
       -----
Answer  .1625
```

EXAMPLE IV.

Multiply .17 by .06.

```
        .17
        .06
       -----
Answer .0102
```

In each of the factors are two decimals the product ought therefore to contain 4 and, there being only three figures in the product, a cipher must be prefixed.

EXAMPLE V.

Multiply .18 by 24.

```
         .18
         24
        ----
         72
        36
        ----
Answer  4.32
```

EXAMPLE VI.

Multiply 36.1 by 2.5.

```
        36.1
         2.5
       ------
        18.05
        72.2
       ------
Answer  90.25
```

DIVISION OF DECIMALS.

Division of decimals is performed in the same manner as in whole numbers; only observing that the number of decimals in the quotient must be equal to the excess of the number of decimals of the dividend above those of the divisor. When the divisor contains more decimals than the dividend, ciphers must be affixed to the right hand of the latter to make the number equal or exceed that of the divisor.

EXAMPLE I.

Divide 14.625 by 3.25.

```
3.25 ) 14.625 ( 4.5
       1300
       ----
        1625
        1625
```

In this example, there are two decimals in the divisor, and three in the dividend; hence there is one decimal in the quotient.

EXAMPLE II.

Divide 3.1 by .0062.

Previous to the division, I affix a number of ciphers to the right hand of 3.1, which does not alter its value.

```
.0062 ) 3.100000 ( 500.00
        310
        -----
        00000
```

Therefore the answer is 500 00 or 500.

Digitized by Google

EXAMPLE III.

Divide 0.35 by 0.7.

```
.7 ) .35 ( .5
     .35
```

EXAMPLE IV.

Divide 9.6 by .06.

```
.06 ) 9.60
      160 Answer.
```

Here, by affixing a cipher to 9.6, it becomes 9.60, and has then two decimals in it, which is the same number as is in the divisor; therefore the quotient is an integral number.

EXAMPLE V.

Divide 17.256 by 1.16.

```
1.16 ) 17.25600 ( 14.875
       116
       ---
        565
        464
        ---
        1016
         928
        ----
          880
          812
          ---
           680
           580
           ---
           100
```

REDUCTION OF DECIMALS.

If you wish to reduce a vulgar fraction to a decimal, you may add any number of ciphers to the numerator, and divide it by the denominator; the quotient will be the decimal fraction; the decimal point must be so placed that there may be as many figures to the right hand of it as you added ciphers to the numerator; if there are not as many figures in the quotient, you must place ciphers to the left hand to make up the number

EXAMPLE I.

Reduce $\frac{1}{5}$ to a decimal.

```
5 ) 1.0
     .2 Answer.
```

EXAMPLE II.

Reduce $\frac{3}{8}$ to a decimal.

```
8 ) 3.000
     .375 Answer.
```

EXAMPLE III.

Reduce 3 inches to the decimal of a foot.

Since 12 inches = 1 foot, this fraction is $\frac{3}{12}$.

```
12 ) 3.00
      .25 Answer.
```

EXAMPLE IV.

Reduce $3\frac{1}{2}$ inches to the decimal of a foot.

$3\frac{1}{2} = \frac{7}{2}$; this divided by 12 is $\frac{7}{24}$.

```
24 ) 7.000 ( .291 Answer, nearly.
     48
     ---
     220
     216
     ---
      40
      24
      --
      16
```

EXAMPLE V.

Reduce 1 foot and 6 inches to the decimal of a yard.

Here 1 foot 6 inches = 18 inches.

And 1 yard = 36 inches; therefore this fraction is $\frac{18}{36}$.

```
36 ) 18.0 ( .5 Answer.
     180
```

If you have any decimal fraction, it is easy to find its value in the lower denominations of the same quantity; thus, if the fraction was the decimal of a yard, by multiplying it by 3 we have its value in feet and parts; if we multiply this by 12, the product is its value in inches and parts; and in the same manner the values may be obtained in other cases.

EXAMPLE VI.

Required the value of 3.25 yards.

```
3.25
   3
----
 .75
  12
----
9.00
```

Answer, 3 yards, 0 feet, 9 inches.

EXAMPLE VII.

Required the value of 7.231 days

```
7.231
   24
-----
  924
 462
-----
5.544
   60
------
32.640
    60
------
38.400
```

Answer, 7 days, 5 hours, 32 minutes, 38 seconds, and 4 tenths of a second.

Digitized by Google

GEOMETRY.

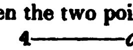
GEOMETRY is the science which treats of the description, properties, and relations of magnitudes in general, of which there are three kinds or species; viz. a *line*, which has only length without either breadth or thickness; a *superficies*, comprehended by length and breadth; and a *solid*, which has length, breadth, and thickness.

I.

A POINT, considered mathematically, has no length, breadth, or thickness.

II.

A STRAIGHT LINE, or RIGHT LINE, is the shortest distance between the two points which limit its length, as AC.

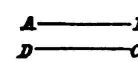


III.

A PLANE SUPERFICIES is that in which any two points being taken, the straight line between them lies wholly in that surface.

IV.

PARALLEL LINES are such as are in the same plane, and which, extended infinitely, do never meet, as AB, DC.

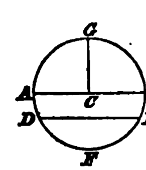


V.

A CIRCLE is a plane figure, bounded by a uniform curve line, it is commonly described with a pair of compasses; one point of which is fixed, whilst the other is turned round to the place where the motion first began; the fixed point is called the CENTRE, and the line described by the other point is called the CIRCUMFERENCE

VI.

The RADIUS of a circle, or SEMI-DIAMETER, is a right line drawn from the centre to the circumference, as AC; or it is that line which is taken between the points of the compasses to describe the circle.



A DIAMETER of a circle is a right line drawn through the centre, and terminated at both ends by the circumference, as ACB; and is the double of the radius, AC. A diameter divides the circle and its circumference into two equal parts.

VII.

An ARC of a circle is any part or portion of the circumference, as DFE.

VIII.

The CHORD of an arc is a straight line joining the ends of the arc; it divides the circle into two unequal parts, called SEGMENTS, and is a chord to them both; as DE is the chord of the arcs DFE and DGE.

IX.

A SEMICIRCLE, or half circle, is a figure contained under a diameter and the arc terminated by that diameter, as AGB or AFB. Any part of a circle contained between two radii and an arc, is called a SECTOR.

X.

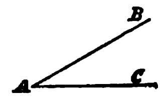
A QUADRANT is half a semicircle, or one fourth part of a whole circle, as the figure CAG.

Note. All circles, whether great or small, are supposed to have their circumference divided into 360 equal parts, called degrees; and each degree into 60 equal parts, called minutes; and each minute into 60 equal parts, called seconds; and so on into thirds,

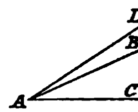
Digitized by Google

fourths,[*] &c.; and an arc is said to be of as many degrees as it contains parts of the 360, into which the circumference is divided.

XI.

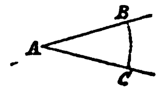


An ANGLE is the inclination of two lines which meet, but not in the same direction.



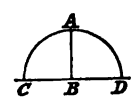
An angle is usually expressed by the letter placed at the angular point, as the angle A. But when two or more angles are at the same point, it is then necessary to express each by three letters, and the letter at the angular point is placed between the other two. Thus the angle formed by the lines AB, AC, is called the angle BAC, or CAB; and that formed by AB, AD, is called the angle BAD, or DAB.

An angle is measured by the arc of a circle comprehended between the two legs that form the angle; the centre of the circle being the angular point, and the whole circumference considered as equal to 360°.



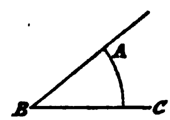
Thus the angle A is measured by the arc BC described round the point A as a centre, and the angle is said to be of as many degrees as the arc is; that is, if the arc BC is 30°, then the angle BAC is said to be an angle of 30 degrees.

XII.



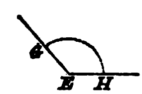
If a right line, AB, fall upon another, DC, so as to incline neither to the one side nor the other, but makes the angles ABC, ABD, equal to each other, then the line AB is said to be *perpendicular* to the line DC, and each of these angles is called a *right angle*, being each equal to a quadrant, or 90°; because the sum of the two angles, ABC, ABD, is measured by the semicircle DAC, described on the diameter DBC, and centre B.

XIII.



An ACUTE ANGLE is less than a right angle, as ABC.

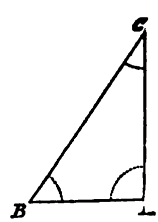
XIV.



An OBTUSE ANGLE is greater than a right angle, as GEH.

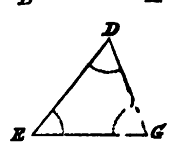
The least number of right lines that can include a space are three, which form a figure called a *triangle*, consisting of six parts, viz. three sides and three angles; it is distinguished into three sorts, viz. a *right-angled triangle*, an *obtuse-angled triangle*, and an *acute-angled triangle*.

XV.



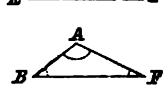
A RIGHT-ANGLED TRIANGLE has one of its angles right; the side opposite the right angle is called the *hypotenuse;* and the other two sides are called legs; that which stands upright is called the *perpendicular*, and the other the *base;* thus BC is the hypotenuse, AC the perpendicular, and AB the base; the angles opposite the two legs are both acute.

XVI.



An ACUTE-ANGLED TRIANGLE has each of its angles acute, as DEG.

XVII.



An OBTUSE-ANGLED TRIANGLE has one of its angles obtuse, or greater than a right angle, as BAF; the other two angles are acute.

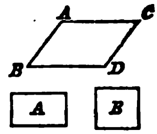
Note. All triangles that are not right-angled, whether they are acute or obtuse, are in general called *oblique-angled triangles*, without any other distinction.

---

[*] A new division of the circumference of the circle has lately been adopted by several eminent French mathematicians, in which the quadrant is divided into 100°, each degree into 100′, each minute into 100″, &c., and tables of logarithms have been published conformable thereto. The general adoption of this division would tend greatly to facilitate most of the calculations of navigation and astronomy.

Digitized by Google

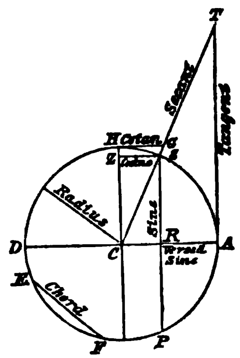
XVIII.



A QUADRILATERAL figure is one bounded by four sides, as ACDB. If the opposite sides are parallel, they are called PARALLELOGRAMS. Thus, if AC be parallel to BD, and AB parallel to CD, the figure ACDB is a parallelogram. A parallelogram having all its sides equal, and its angles right, is called a SQUARE, as B. When the angles are right, and the opposite sides only equal, it is called a RECTANGLE, as A

XIX.

The SINE of an arc is a line drawn from one end of the arc perpendicular to a diameter drawn through the other end of the same arc; thus RS is the sine of the arc AS, RS being a line drawn from one end, S, of that arc, perpendicular to DA, which is the diameter passing through the other end, A, of the arc.



XX.

The COSINE of an arc is the sine of the *complement* of that *arc*, or of what that arc wants of a quadrant; thus, AH being a quadrant, the arc SH is the complement of the arc AS; SZ is the sine of the arc SH, or the cosine of the arc AS.

XXI.

The VERSED SINE of an arc is that part of the diameter contained between the sine and the arc; thus RA is the versed sine of the arc AS and DCR is the versed sine of the arc DHS.

XXII.

The TANGENT of an arc is a right line drawn perpendicular to the diameter, passing through one end of the arc, and terminated by a line drawn from the centre through the other end of the arc; thus AT is the tangent of the arc AS.

XXIII.

The COTANGENT of an arc is the tangent of the complement of that arc to a quadrant; thus HG is the tangent of the arc HS, or the cotangent of the arc AS.

XXIV.

The SECANT of an arc is a right line drawn from the centre through one end of the arc to meet the tangent drawn from the other end; thus CT is the secant of the arc AS.

XXV.

The COSECANT of an arc is the secant of the complement of that arc to a quadrant; thus CG is the secant of the arc SH, or cosecant of the arc AS.

XXVI.

What an arc wants of a semicircle is called the SUPPLEMENT of the arc; thus the arc DHS is the supplement of the arc AS. The sine, tangent, or secant of an arc, is the same as the sine, tangent, or secant of its supplement; thus the sine of $80° =$ sine of 100°, and the sine of $70° =$ sine of 110°, &c.

XXVII.

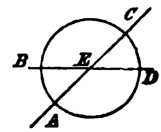
If one line, AB, *fall any way upon another*, CD, *the sum of the two angles*, ABD, ABC, *is always equal to two right angles.*

For, on the point B as a centre, describe the circular arc CAD, cutting the line CD in C and D; then (by *Art.* 6), this arc is equal to a semicircle, but it is also equal to the sum of the arcs CA and AD, the measures of the two angles ABC, ABD; therefore the sum of the two angles is equal to a semicircle, or two right angles. Hence it is evident that all the angles which can be made from a point in any line, towards one side of the line, are equal to two right angles, and that all the angles which can be made about a point, are equal to four right angles.

Digitized by Google

XXVIII.

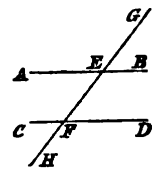
If a line, AC, *cross another,* BD, *in the point* E, *the opposite angles will be equal, viz* BEA = CED, *and* BEC = AED.



Upon the point E as a centre, describe the circle ABCD; then it is evident that ABC is a semicircle, as also BCD (by *Art.* 6); therefore the arc ABC = arc BCD; taking from both the common arc BC, there remains arc AB = arc CD; that is, the angle BEA is equal to the angle CED. After the same manner we may prove that the angle BEC is equal to the angle AED.

XXIX.

If a line, GH, *cross two parallel lines,* AB, CD, *it makes the external opposite angles equal to each other; viz.* GEB = CFH, *and* AEG = HFD.



For since AB and CD are parallel to each other, they may be considered as one broad line, and GH crossing it; then the vertical or opposite angles, GEB, CFH, are equal (by *Art.* 28), as also AEG = HFD.

XXX.

If a line, GH, *cross two parallel lines,* AB, CD (see the figure), *the alternate angles,* AEF *and* EFD, *or* CFE *and* FEB, *are equal.*

For GEB = AEF (*Art.* 28), as also CFH = EFD (by the same *Art.*), but GEB = CFH by the last; therefore AEF is equal to EFD; in the same way may we prove FEB = CFE.

XXXI.

If a line, GH, *cross two parallel lines,* AB, CD (see the preceding figure), *the external angle,* GEB, *is equal to the internal opposite one,* EFD, *or* AEG *equal to* CFE.

For the angle AEF is equal to the angle EFD by the last, and AEF = GEB (by *Art.* 28); therefore GEB = EFD; in the same way we may prove AEG = CFE.

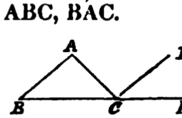
XXXII.

If a line, GH, *cross two parallel lines,* AB, CD (see the preceding figure), *the sum of the two internal angles,* BEF *and* DFE, *or* AEF *and* CFE, *is equal to two right angles.*

For since the angle GEB is equal to the angle EFD (by *Art.* 31), to both add the angle BEF, and we have GEB + BEF = BEF + EFD; but GEB + BEF = two right angles (*Art.* 27). Hence, BEF + EFD = two right angles; and in the same manner we may prove AEF + CFE = two right angles.

XXXIII.

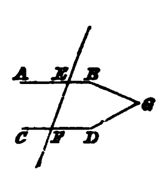
In any triangle, ABC, *one of its legs, as* BC, *being produced towards* D, *the external angle,* ACD, *is equal to the sum of the internal and opposite angles,* ABC, BAC.



To prove this, through C draw CE parallel to AB; then, since CE is parallel to AB, and the lines AC, BD cross them, the angle ECD = ABC (by *Art.* 31), and ACE = BAC (by *Art.* 30); adding these together we have ECD + ACE = ABC + BAC; but ECD + ACE = ACD; therefore ACD = ABC + BAC.

XXXIV.

Hence it may be proved that if any two lines, AB *and* CD, *be crossed by a third line,* EF, *and the alternate angles,* AEF *and* EFD, *be equal, the lines* AB *and* CD *will be parallel.*



For, if they are not parallel, they must meet each other on one side of the line EF (suppose at G), and so form the triangle EGF, one of whose sides, GE, being produced to A, the exterior angle, AEF, must (by the preceding article) be equal to the sum of the two angles EFG and EGF; but by supposition it is equal to the angle EFG alone; therefore the angle AEF must be equal to the sum of the two angles EFG and EGF, and at the same time equal to EFG alone, which is absurd; therefore the lines AB, CD, cannot meet, and must be parallel.

Digitized by Google

XXXV.

In any right-lined triangle, ABC, *the sum of the three angles is equal to two right angles.*

To prove this, you must produce BC (in the fig. *Art.* 33) towards D; then (by *Art.* 33), the external angle ACD = ABC + BAC; to both add the angle ACB, and we have ACD + ACB = ABC + BAC + ACB; but ACD + ACB = two right angles (by *Art.* 27). Hence, ABC + BAC + ACB = two right angles; therefore the sum of the three angles of any plain triangle, ACB, is equal to two right angles.

XXXVI.

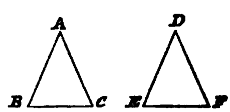
Hence in any plain triangle, if one of its angles be known, the sum of the other two will be also known.

For by the last article the sum of all three angles is equal to two right angles, or 180°; hence, by subtracting the given angle from 180°, the remainder will be the sum of the other two.

In any right-angled triangle, the two acute angles taken together are just equal to a right angle; for, all three angles being equal to two right angles, and one angle being right by supposition, the sum of the other two must be equal to a right angle; consequently, any one of the acute angles being given, the other one may be found by subtracting the given one from 90 degrees.

XXXVII.

If in any two triangles, ABC, DEF, *two legs of the one,* AB, AC, *be equal to two legs of the other,* DE, DF, *each to each respectively, that is,* AB = DE, *and* AC = DF, *and the angles* BAC, EDF, *included between the equal legs be equal; then the remaining leg of the one will be equal to the remaining leg of the other, and the angles opposite to the equal legs will be equal; that is,* BC = EF, ABC = DEF, *and* ACB = DFE.



For if the triangle ABC be supposed to be lifted up and put upon the triangle DEF, with the point A on the point D, and the line AB upon DE, it is plain, since AB = DE, that the point B will fall upon E; and since the angles BAC, EDF are equal, the line AC will fall upon DF; and these lines being of equal length, the point C will fall upon F; consequently the line BC will fall exactly upon the line EF, and the triangle ABC will in all respects be exactly equal to the triangle DEF, and the angle ABC will be equal to the angle DEF, also the angle ACB will be equal to the angle DFE.

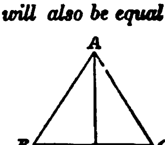
XXXVIII.

After the same manner it may be proved that if in any two triangles, ABC, DEF (see the preceding figure), *two angles,* ABC *and* ACB, *of the one be equal to two angles,* DEF, DFE, *of the other, and the included side,* BC, *be equal to* EF, *the remaining sides and included angles will also be equal to each other respectively; that is,* AB = DE, AC = DF, *and the angle* BAC = *the angle* EDF.

For if the triangle ABC be supposed to be lifted up and laid upon the triangle DEF, the point B being upon the point E, and the line BC upon the line EF, then, since BC = EF, the point C will fall upon the point F; and, as the angle ACB = the angle DFE, the line CA will fall upon the line FD; by the same way of reasoning, the line BA will fall upon the line ED; therefore the point of intersection, A, of the two lines, BA, CA, will fall upon D, the point of intersection of the lines ED, FD; consequently AB = DE, AC = DF, and the angle BAC = the angle EDF.

XXXIX.

If two sides of a triangle are equal, the angles opposite these sides will also be equal; that is, if AB = AC, *the angles* ABC, ACB, *will also be equal.*



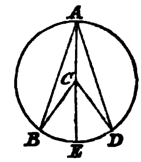
For, draw the line AD, bisecting the angle BAC, and meeting the line BC in D, dividing the triangle BAC into two triangles, ABD, ACD, in which the side AB = AC, the side AD is common to both triangles, and the angle BAD = the angle DAC; consequently (by *Art.* 37), the angle ABD must be equal to the angle ACD.

The converse of this proposition is also true; that is, *if two angles of a triangle are equal, the opposite sides are also equal.* This is demonstrated nearly in the same manner, by means of *Art.* 38.

Digitized by Google

XL.

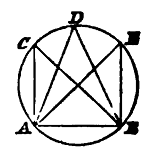
Any angle at the circumference of a circle is equal to half the angle at the centre, standing upon the same arc.



Thus the angle BAD is half the angle BCD, standing upon the same arc, BD, of the circle BEDA whose centre is C. To demonstrate this, draw through A and the centre C, the right line ACE; then (by *Art.* 33) the angle CAD + angle CDA = angle ECD; but AC = CD (being two radii of the same circle); therefore (by *Art.* 39), the angle CAD = the angle CDA, and the sum of these two angles is the double of either of them; that is, CAD + CDA = twice CAD; therefore ECD = twice CAD; in the same manner it may be proved that BCE = twice BAC, and by adding these together, we have ECD + BCE = twice CAD + twice BAC; that is, BCD = twice BAD, or BAD equal to half of BCD. The demonstration is similar when B, D, fall on the same side of E.

XLI.

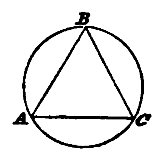
An angle at the circumference is measured by half the arc it subtends.



For an angle at the centre, standing on the same arc, is measured by the whole arc (by *Art.* 11); but since an angle at the centre is double that at the circumference (*Art.* 40), it is evident that an angle at the circumference must be measured by half the arc it stands upon. *Hence all angles,* ACB, ADB, AEB, &c., *at the circumference of a circle standing on the same chord,* AB, *are equal to each other;* for they are all measured by the same arc, viz. half the arc AB.

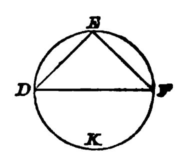
XLII.

An angle in a segment greater than a semicircle is less than a right angle.



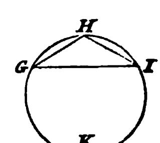
Thus, if ABC be a segment greater than a semicircle, the arc AC on which it stands must be less than a semicircle, and the half of it less than a quadrant or a right angle; but the angle ABC in the segment is measured by the half of the arc AC; therefore it is less than a right angle.

An angle in a semicircle is a right angle.



For since DEF is a semicircle, the arc DKF must also be a semicircle; but the angle DEF is measured by half the arc DKF, that is, by half a semicircle or by a quadrant; therefore the angle DEF is a right one.

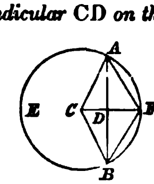
An angle in a segment less than a semicircle is greater than a right angle.



Thus, if GHI be a segment less than a semi-circle, the arc GKI on which it stands must be greater than a semicircle, and its half greater than a quadrant or right angle; therefore the angle GHI, which is measured by half the arc GKI is greater than a right angle.

XLIII.

If from the centre, C, *of the circle* ABE *there be let fall the perpendicular* CD *on the chord* AB, *it will bisect the chord in the point* D.



Draw the radii CA, CB; then (by *Art.* 39) the angle CBA = the angle CAB, and as the angles at D are right, the angle ACD must be equal to the angle BCD (by *Art.* 36). Hence in the triangles ACD, BCD, we have the angle ACD equal to the angle BCD, CA = CB, and CD common to both triangles, consequently (by *Art.* 37) AD = DB; that is, AB is bisected at D.

XLIV.

If from the centre, C, *of the circle* ABE *there be drawn a perpendicular* CD, *to the chord* AB, *and it be continued to meet the circle in* F, *it will bisect the arc* AFB *in* F (See the preceding figure.)

For in the last article it was proved that the angle ACD = the angle BCD; hence (by *Art.* 11) the arc AF = the arc FB.

Digitized by Google

XLV.

Any line bisecting a chord at right angles is a diameter.

For since (by *Art.* 43) a line drawn from the centre perpendicular to a chord, bisects that chord at right angles, therefore conversely a line bisecting a chord at right angles, must pass through the centre, and consequently be a diameter.

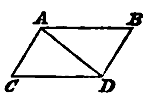
XLVI.

The sine of any arc is equal to half the chord of twice that arc.

For (in the last scheme) AD is the sine of the arc AF, and AF is equal to half the arc AFB, and AD half the chord AB; hence the proposition is manifest.

XLVII.

If two equal and parallel lines, AB, CD, *be joined by two others,* AC, BD, *these will be also equal and parallel.*



To demonstrate this, join the two opposite angles A and D with the line AD; then it is evident, that the line AD divides the quadrilateral ACDB into two triangles, ABD, ACD, in which AB is equal to CD, by supposition, and AD is common to both triangles; and since AB is parallel to CD, the angle BAD is equal to the angle ADC (by *Art.* 30); therefore, in the two triangles, the sides AB, AD, and the angle BAD, are equal respectively to the sides CD, AD, and the angle ADC; hence (by *Art.* 37) BD is equal to AC, and the angle DAC equal to the angle ADB; therefore (by *Art.* 34) the lines BD, AC, must be parallel.

Cor. Hence it follows, that the quadrilateral ABDC is a parallelogram, since the opposite sides are parallel. It is also evident that, in any parallelogram, the line joining the opposite angles (called the *diagonal*), as AD, divides the figure into two equal parts, since it has been proved that the triangles ABD ACD, are equal to each other.

XLVIII.

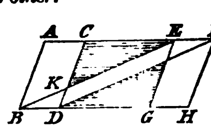
It follows also from the preceding article, that *a triangle,* ACD (see the preceding figure), *on the same base, and between the same parallels with a parallelogram,* ABDC, *is the half of that parallelogram.*

XLIX.

From the same article it also follows, that *the opposite sides of a parallelogram are equal;* for it has been proved, that, ABDC being a parallelogram, AB is equal to CD, and AC equal to BD.

L.

All parallelograms on the same or equal bases, and between the same parallels, are equal to each other; that is, if BD *and* GH *be equal, and the lines* BH, AF, *be parallel, the parallelograms* ABDC, BDFE, *and* EFHG, *will be equal to each other.*



For AC is equal to EF, each being equal to BD (by *Art.* 49); to both add CE, and we have AE, equal to CF; therefore in the two triangles ABE, CDF, AB is equal to CD, AE is equal to CF, and the angle BAE is equal to DCF (by *Art.* 31); therefore the two triangles ABE, CDF, are equal (by *Art.* 37), and taking the triangle CKE from both, the figure ABKC is equal to the figure KDFE, to both which add the triangle KBD, and we have the parallelogram ABDC, equal to the parallelogram BDFE. In the same way it may be proved that the parallelogram EFHG is equal to the parallelogram BDFE; therefore the three parallelograms ABDC, BDFE, and EFHG, are equal to each other.

Cor. Hence it follows, that *triangles on the same base, and between the same parallels, are equal,* since they are the half of the parallelograms on the same base and between the same parallels (by *Art.* 48).

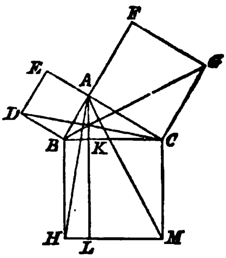
LI.

In any right-angled triangle, the square of the hypotenuse is equal to the sum of the squares of the two sides. Thus, if BAC *be a right-angled triangle, the square of the hypotenuse* BC, *viz.* BCMH, *is equal to the sum of the squares made on the two sides,* AB *and* AC, *viz. to* ABDE *and* ACGF.

To demonstrate this, through the point A draw AKL perpendicular to the hypotenuse BC. Join AH, AM, DC, and BG; then it is evident, that DB is equal to BA (by *Art.* 18

Digitized by Google

and BH equal to BC; therefore in the triangles DBC, ABH, the two legs, DB, BC, of the one, are equal to the two legs, AB, BH, of the other; and the included angles, DBC and ABH, are also equal; (for DBA is equal to CBH, being both right; to each add ABC, and we have DBC, equal to ABH); therefore the triangles DBC, ABH, are equal (by *Art.* 37); but the triangle DBC is half of the square ABDE (by *Art.* 48), and the triangle ABH is half the parallelogram BKLH (by the same article); consequently the square ABDE is equal to the parallelogram BKLH. In the same way it may be proved that the square ACGF is equal to the parallelogram KCML. Therefore the sum of the squares ABDE and ACGF is equal to the sum of the parallelograms BKLH and KCML; but the sum of these parallelograms is equal to the square BCMH; therefore the sum of the squares on AB and AC is equal to the square on BC.



Cor. Hence, in any right-angled triangle, if we have the hypotenuse and one of the legs, we may easily find the other leg, by taking the square of the given leg from the square of the hypotenuse; the square root of the remainder will be the sought leg. Thus, if the hypotenuse was 13, and one leg was 5, the other leg would be 12, for the square of 5 is 25, and the square of 13 is 169; subtracting 25 from 169 leaves 144, the square root of which is 12. If both legs are given, the hypotenuse may also be found by extracting the square root of the sum of the squares of the legs; thus, if one leg was 6, and the other 8, the square of the first is 36, the square of the second is 64; adding 36 and 64 together gives 100, whose square root is 10, which is the sought hypotenuse.

LII.

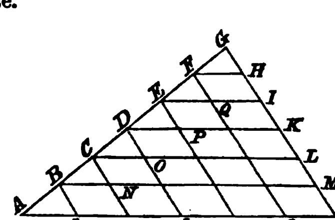
Four quantities are said to be proportional, when the magnitude of the first compared with the second is the same as the magnitude of the third compared with the fourth.

Thus 4, 8, 12, and 24, are proportional, because 4 is half of 8, and 12 is half of 24; and if we take equi-multiples, $A \times a$, $A \times b$, of the quantities a and b, and other equi-multiples, $B \times a$, $B \times b$, of the same quantities a and b, the four quantities, $A \times a$, $A \times b$, $B \times a$, $B \times b$, will be proportional; for $A \times a$ compared with $A \times b$ is of the same magnitude as a compared with b, and $B \times a$ compared with $B \times b$ is also of the same magnitude as a compared with b.

LIII.

In any triangle, AGg, *if a line,* Ee, *be drawn parallel to either of the sides, as* Gg, *the side* AG *will be to* AE *as* Ag *to* Ae, *or as* Gg *to* Ee.

To demonstrate this, upon the line AG take the line AB so that a certain multiple of it may be equal to AE, and another multiple of it may be equal to AG; this may be always done accurately when AE and AG are commensurable; if they are not accurately commensurable, the quantity AB may be taken so small that certain multiples of it may differ from AE and AG respectively by quantities less than any assignable. On the line AG, take BC, CD, DE, EF, FG, &c., each equal to AB; and through these points draw the lines Bb, Cc, &c., parallel to Gg, cutting the line Ag in the points b, c, d, e, &c.; draw also the lines BM, CL, DK, &c., parallel to Ag, cutting the former parallels in the points N, O, P, &c., and the line Gg in the points M, L, K, &c. Then the triangles ABb, BCN, CDO, &c., are similar and equal to each other; for the lines Bb, CN, are parallel; therefore the angle ABb = BCN (by *Art.* 31), and by the same article the angle BAb is equal to CBN (because BN is parallel to Ab), and by construction AB = BC; therefore (by *Art.* 38) the triangles ABb and BCN are equal to each other; and in the same manner we may prove that the others, CDO, DEP, EFQ, &c., are equal to ABb. Therefore Ab = BN = CO = DP, &c., and Bb = CN = DO = EP, &c.; but (by *Art.* 49) BN = bc, CO = cd, DP = de; therefore Ab = bc = cd = de, &c.; and since (by construction) AB = BC = CD, &c., any line AE is the same multiple of AB as the corresponding line Ae is of Ab; and AG is the same multiple of AB as Ag is of Ab; therefore the lines AG, AE, Ag, Ae, are

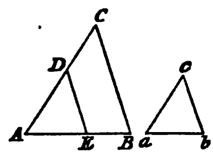


Digitized by Google

proportional (by *Art.* 52); that is, AG is to AE as Ag is to Ae; and in a similar manner we may prove that AG is to AE as Gg is to Ee.

LIV.

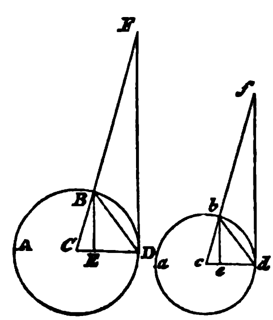
If any two triangles, ABC, abc, *are similar, or have all the angles of the one equal to all the angles of the other, each to each respectively, that is*, CAB = cab, ACB = acb, ABC = abc; *the legs opposite to the equal angles will be proportional, viz.* AB : ab :: AC : ac; AB : ab :: BC : bc; *and* AC : ac :: BC : bc.



To prove this, set off, upon a side, AB, of the largest triangle, AE = ab, and through E draw ED parallel to BC, to meet AC in D; then since DE, BC, are parallel, the angle AED is equal to ABC (by *Art.* 31), and this (by supposition) is equal to the angle abc; also the angle DAE is (by supposition) equal to cab; therefore in the triangles ADE, abc, the two angles, DAE, AED, of the one, are equal to the two angles, cab, abc, of the other, each to each respectively, and the included side AE is (by construction) equal to the included side ab; therefore (by *Art.* 38) AD is equal to ac, and DE equal to bc; but since, in the triangle ABC, there is drawn DE parallel to BC, one of its sides, to meet the other two sides in the points DE, therefore (by the preceding article) AB : AE :: AC : AD, and AB : AE :: BC : DE, and AC : AD :: BC : DE; if, in these three proportions, for DE we put its equal bc, for AE put ab, and for AD put ac, they will become AB : ab :: AC : ac, and AB : ab :: BC : bc, and AC : ac :: BC : bc.

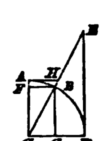
LV.

The chord, sine, tangent, &c., of any arc in one circle, is to the chord, sine, tangent, &c., of the same arc in another, as the radius of the one is to the radius of the other.



Let ABD, abd, be two circles; BD, bd, two arcs of these circles, equal to one another, or consisting of the same number of degrees; also FD, fd, the tangents; BD, bd, the chords; BE, be, the sines, &c., of these two arcs BD, bd; and CD, cd, the radii of the circles; then CD : cd :: FD : fd, and CD : cd :: BD : bd, and CD : cd :: BE : be, &c. For since the arcs BD, bd, are equal, the angles BCD, bcd, are also equal, and FD, fd, being tangents to the points D and d, the angles CDF, cdf, are each equal to a right angle (by *Art.* 22); therefore, since in the two triangles CDF, cdf, the two angles FCD, CDF, of the one, are equal to the two angles, fcd, cdf, of the other, each to each, the remaining angle, CFD, is also equal to the remaining angle, cfd (by *Art.* 36); consequently the triangles CFD, cfd, are similar. The triangles BCD, bcd, are also similar, for the angle CBD is equal to the angle CDB, being each subtended by the radius; therefore (by *Art.* 36), each of these angles is equal to half the supplement of the angle BCD and in the same manner the angle cbd or cdb is equal to half the supplement of the angle bcd; and since the angle BCD is equal to bcd, the angles of these two triangles must be equal; consequently they are similar. The triangles BCE, bce, are also similar because BE is parallel to FD, and be parallel to fd. Hence we obtain (by *Art.* 54) the following analogies. CD : cd :: FD : fd; CD : cd :: BD : bd; CB : cb :: BE : be, &c.

LVI.

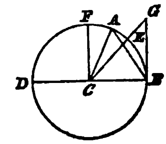


Let ABD be a quadrant of a circle, described by the radius CD, BD any arc of it, BA its complement, BG or CF the sine, CG or BF the cosine, DE the tangent, AH the cotangent, CE the secant, and CH the cosecant of that arc BD. Then, since the triangles CDE, CGB, are similar, we shall have (by *Art.* 54) DE : CE :: BG : CB; that is, the tangent of an arc is to secant of the same as the sine of it is to radius. Also, CE : CD :: CB : CG; that is, the secant is to radius as the radius to the cosine of the arc. Also, CF : CA :: CB : CH; that is, the sine is to radius as radius to the cosecant of the arc; and since the triangle CAH is similar to the triangle CDE, we have AH : CA :: CD : DE; that is, the cotangent is to the radius as the radius to the tangent of the arc

Digitized by Google

LVII.

In all circles, the sine of 90°, the tangent of 45°, and the chord of 60°, are each equal to the radius.

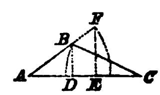


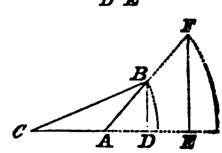
For, in the circle DFAEB, let the arc BE be 45°, the arc BA 60°, and BF 90°. Draw through the centre, C, the diameter DCB, and perpendicular thereto the tangent BG, meeting CE produced in G; draw the chord BA, and join CF, CA. Then, since the arc BF is 90° DF must be 90°; whence (by *Art.* 12 and 19) the radius CF is equal to the sine of the arc BF, or sine of 90°. Again, in the triangle CBG, since the angle CBG is 90°, and BCG is 45°, by supposition, the angle CGB is also 45° (by *Art.* 36); therefore (by *Art.* 39) BG is equal to CB; that is, the tangent of 45° is equal to the radius. Again, the angle ACB is 60° (being measured by the arc BA), and the angle CBA is also 60° (being measured by half the arc AD = 120°, by *Art.* 40); therefore (by *Art.* 39) CA = AB; that is, the chord of 60° is equal to the radius.

The four following propositions contain the demonstration of the rules by which all the calculations of trigonometry may be made; they are inserted here in order to prevent any embarrassment of the young calculator, from the introduction of the demonstrations among the precepts for calculation.

LVIII.

In any plane triangle, the sides are proportional to the sines of the opposite angles

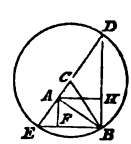




Let ABC be the triangle; produce the shorter side, AB, to F, making AF equal to BC; from B and F let fall the perpendiculars BD, FE, upon AC (produced if necessary); then FE is the sine of the angle A, and BD is the sine of the angle C, the radius being BC, equal to AF; now, the triangles ABD, AFE, having the angle A common to both, and the angle D equal to the angle E (being each equal to a right angle), are similar; hence (by *Art.* 54), as AF (or its equal BC) is to AB, so is FE to BD; that is, BC is to AB as the sine of the angle A is to the sine of the angle C.

LIX.

In any triangle (supposing any side to be the base, and calling the other two the sides), the sum of the sides is to their difference as the tangent of half the sum of the angles at the base is to the tangent of half the difference of the same angles.



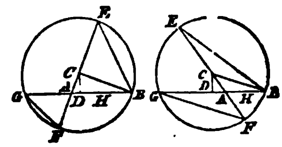
Thus, in the triangle ABC, if we call AB the base, it will be, As the sum of AC and CB is to their difference, so is the tangent of half the sum of the angles ABC, BAC, to the tangent of half their difference.

Dem. With the longest leg, CB, as radius, describe a circle about the centre, C, meeting the shorter side, AC (produced on each side), in the points D and E; join EB, DB; draw AH perpendicular to DB, and AF perpendicular to EB; then (by *Art.* 42) the angle EBD, being in a semicircle, is a right angle; and the triangles AHD, AFE, are similar and AF is equal to HB. Moreover, since CB is equal to CD or CE, AD is the sum and AE is the difference of the legs AC, CB; likewise (by *Art.* 33) the angle BCD is equal to the sum of the angles BAC, ABC, and therefore (by *Art.* 40), the angle DEB, or its equal DAH, is equal to half the sum of the angles at the base ABC, BAC. Again (by *Art.* 33) the angle BAC is equal to the sum of the angles CEB (or CBE) and ABE, and therefore is equal to the sum of the angle ABC, and twice the angle ABE; hence the angle ABE, or its equal BAH, is equal to half the difference of the angles at the base. But in the right-angled triangles AHD, AHB, making AH radius, the legs DH, HB, are the tangents of the angles DAH, BAH, or the tangents of half the sum and half the difference of the angles at the base; but by reason of the similar triangles AHD, AFE, we have AD : AE :: DH : AF or HB; that is, AD, the sum of the legs, AC and CB, is to AE, their difference, as DH, the tangent of half the sum of the angles at the base (the radius being AH), is to HB, the tangent of half the difference of the same angles (to the same radius); and therefore (by *Art.* 55) as the tabular tangent of half the sum of the angles at the base is to the tabular tangent of half the difference of the same angles.

Digitized by Google

LX.

In any plane triangle, ABC, if the line CD be drawn perpendicular to the base, AB, dividing it into two segments, AD, DB, and the base, AB, be bisected in the point H, we shall have,

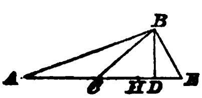


As the base,* AB, *is to the sum of the sides,* AC, BC, *so is the difference of the sides to twice the distance,* DH, *of the perpendicular from the middle of the base.

Dem. With the greater side, CB, as radius, describe about the centre, C, the circle BFGE, meeting the other side produced in the points E and F, and the base AB produced in G; join GF and BE. Then AE is the sum, and AF the difference, of the sides AC, CB; and since CD is perpendicular to GB, the line GB is bisected in D (by *Art.* 43), and as AB is bisected in H, the line AG is equal to twice DH. Now, in the triangles BAE, GAF, the angles ABE, GFA, are equal (by *Art.* 41), and the angle BAE is equal to GAF (by *Art.* 28); therefore the remaining angles AEB, AGF, are equal, and the triangles BAE, GAF, are similar; consequently (by *Art.* 54) AB : AE :: AF : AG, or twice HD, which is the proposition to be demonstrated. Having thus obtained HD, we may find the segments AD, DB, by adding HD to the half base HA or HB, and by taking their difference.

LXI.

In any plane triangle, the square of radius is to the square of the cosine of half of either of the angles, as the rectangle contained by the two sides including that angle, is to the rectangle contained by the half sum of the sides, and that half sum decreased by the side opposite to that angle.



Thus, in the triangle CBE, the square of radius is to the square of the cosine of half the angle C, as the rectangle $CB \times CE$ is to $\frac{(CB+CE+BE)}{2} \times \frac{(CB+CE-BE)}{2}$. For continue EC to A, making $CA = CB$; draw BD perpendicular to CE; bisect CE in H, and join AB. Then (supposing CB to be greater than EB) we have (by *Art.* 60)

$CE : CB + BE :: CB - BE : \frac{CB^2 - BE^2}{CE} = 2 \times HD$; by adding half this to half the base $= CH$, we have the segment $CD = \frac{CB^2 - BE^2 + CE^2}{2 \times CE}$; to this adding CA or CB, we have $AD = \frac{CB^2 - BE^2 + CE^2 + 2CE \times CB}{2 \times CE} = \frac{(CB+CE)^2 - BE^2}{2 \times CE} = \frac{(CB+CE+BE) \times (CB+CE-BE)}{2 \times CE}$. Again, $AD = AC + CD = CB + CD$; hence $AD^2 = CB^2 + 2CB \times CD + CD^2$; also, $BD^2 = CB^2 - CD^2$; hence $AB^2 = AD^2 + BD^2 = 2 \times CB^2 + 2CB \times CD = 2CB \times (CB + CD) = 2CB \times AD$; hence $AB^2 : AD^2 :: 2CB : AD = \frac{(CB+CE+BE) \times (CB+CE-BE)}{2 \times CE}$; but AB being radius, AD is the cosine of the angle A, which is equal to half the angle C (by *Art.* 40); therefore the square of radius is to the square of the cosine of half the angle C as the rectangle $CE \times CB$ is to the rectangle $\frac{(CB+CE+BE)}{2} \times \frac{(CB+CE-BE)}{2}$.

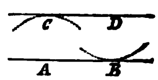
The other cases of this proposition may be demonstrated in the same manner.

Digitized by Google

GEOMETRICAL PROBLEMS.

PROBLEM I.

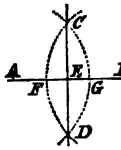
To draw a right line, CD, *parallel to a given right line,* AB, *at any given distance, as at the point* D.



With a pair of compasses take the nearest distance between the point D and the given right line, AB; with that distance set one foot of the compasses any where on the line AB, as at A, and draw the arc C on the same side of the line AB as the point D; from the point D draw a line so as just to touch the arc C, and it is done; for the line CD wil be parallel to the line AB, and at the distance of the point given, D, as was required.

PROBLEM II.

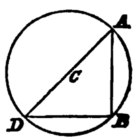
To bisect or divide a given line, AB, *into two equal parts.*



Take any distance in your compasses greater than half the line AB; then, with one foot in B, describe the arc CFD; with the same distance, and one foot in A, describe the arc CGD, cutting the former arc in C and D; draw the line CD, and it will bisect AB in the point E.

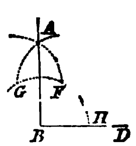
PROBLEM III.

To erect a perpendicular, BA, *on the end of a given right line,* DB.



Take any extent in your compasses, and with one foot in B fix the other in any point, C, without the given line; then, with one point of the compasses in C, describe, with the other, the circle ABD; through D and C draw the diameter DCA, meeting the circle in A; join B and A, and it is done; for BA will be the required line (by *Art.* 42, Geometry).

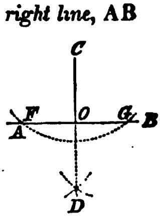
Or thus;



Take any convenient distance, as BH, in your compasses, and, with one foot in B, describe the arc HFG, upon which set off the same distance as a chord from H to F, and from F to G, upon F and G, describe two arcs intersecting each other in A; draw a line from B to A, and it is done; for BA will be the perpendicular required.

PROBLEM IV.

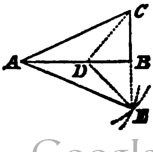
From a given point, as C, *to let fall a perpendicular,* CO, *on a given right line,* AB



Take any extent in your compasses greater than the least distance between C and the given line AB; with one foot in C, describe an arc to cut the given line, AB, in F and G; with one foot in G, describe an arc, and with the same distance, and one foot in F, describe another arc cutting the former in D; from C to D draw the line COD, cutting AB in O; then CO will be the perpendicular required.

PROBLEM V.

From a given point, C, *to let fall a perpendicular,* CB, *on a given line,* AB, *when the perpendicular is to fall so near the end of the given line that it cannot be done as above.*



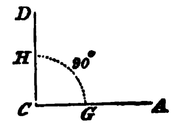
Upon any point, A, of the line AB as a centre, and with the distance AC, describe an arc, E; choose any other point in the line AB, as D, and with the distance DC describe another arc intersecting the former in E; join CE cutting AB in B, and it is done; for CB will be the perpendicular required.

Digitized by Google

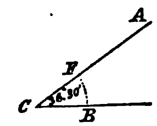
PROBLEM VI.

To make an angle that shall contain any proposed number of degrees, from a given point in a given line.

Case 1. When the given angle is right, or contains 90°, let CA be the given line and C the given point.



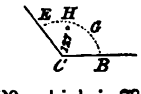
On C erect a perpendicular, CD, and it is done; for the angle DCA is an angle of 90°. Or thus; on the point C, as a centre, with the chord of 60°*, describe an arc, GH, and set off thereon, from G to H, the distance of the chord of 90°, and from C through H draw CHD, which will form the angle DCA of 90° required.



Case 2. When the angle is acute, as, for example, 36° 30′, let CB be the given line, and C the point at which the angle is to be made.

With the chord of 60° in your compasses, and one foot on C, as a centre, draw the arc FB, on which set off, from B to F, the given angle, $36\frac{1}{2}$°, taken from the line of chords; through F and the centre C, draw the right line AC, and it is done; for the angle ACB will be an angle of 36° 30′, as was required.

Case 3. When the given angle is obtuse, as, for example, 127°, let CB be the given line, and C the angular point.

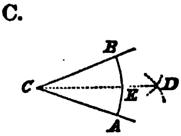


Take the chord of 60° in your compasses, and with one foot on C as a centre, describe an arc, BGHE, upon which set off the chord of 60° (which you already have in your compasses) from B to G, and from G to H; then set off from G to E the excess of the given angle above 60°, which is 67°, taken from the line of chords; or you may set off, from H to E, the excess of the given angle above 120, which is 7°; draw the line CE, and it is done; for the angle ECB will be an angle of 127°

Were it required to measure a given angle, the process would have been nearly the same, by sweeping an arc, as BE, and measuring it on the line of chords, as is evident.

PROBLEM VII.

To bisect a given arc of a circle, AB, *whose centre is* C.

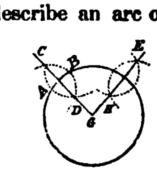


Take in your compasses any extent greater than the half of AB, and, with one foot in A, describe an arc; with the same extent, and one foot in B, describe another arc, cutting the former in D; join CD, and it is done; for this line will bisect the arc AB in the point E. It is also evident that the line CD bisects the angle BCA, or divides it into two equal parts.

PROBLEM VIII.

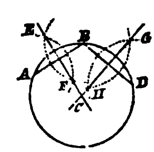
To find the centre of a given circle.

With any radius, and one foot in the circumference, as at A, describe an arc of a circle, as CBD, cutting the given circle in B; with the same extent, and one foot in B, describe another arc, CAD, cutting the former in C and D; through C and D draw the line CD, which will pass through the centre of the circle; in like manner may another right line be drawn, as EHG, which shall cross the first right line at the centre required. This construction depends upon Art. 43 of Geometry.



PROBLEM IX.

To draw a circle through any three given points not situated in a right line.

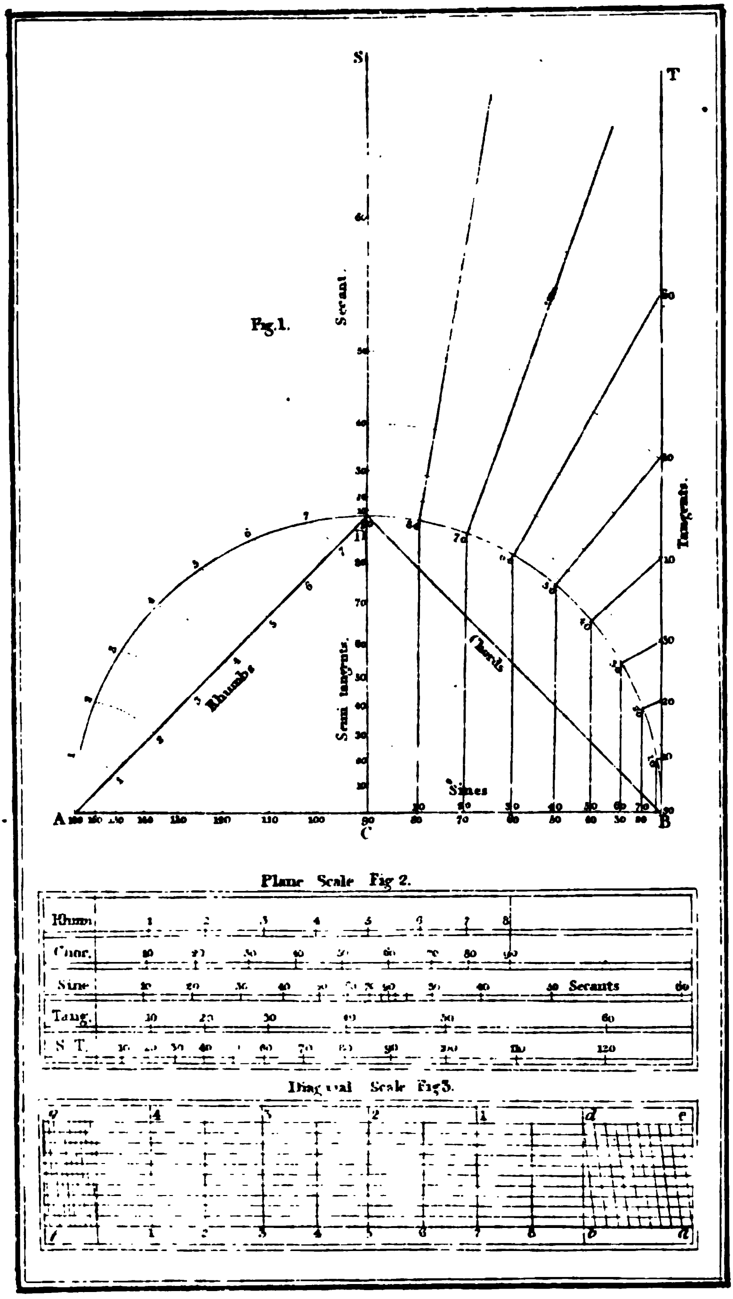


Let A, B, and D, be the given points. Take in your compasses any distance greater than half AB, and, with one foot in A, describe an arc, EF; with the same extent, and one foot in B, describe another arc cutting the former in the points E, F, through which draw the indefinite right line EFC; then take in your compasses any extent greater than half BD, and, with one foot in B, describe an arc, GH; with the same extent, and one foot in D, describe

* For a description of the line of chords, see page 18.

Digitized by Google

Digitized by Google

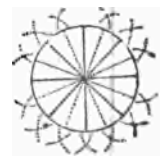


Digitized by Google

another arc cutting the former in the points G, H, through which draw the right line GHC, cutting the former right line EFC in the point C; upon the point C as a centre with an extent equal to CA, CB, or CD, as radius, describe the sought circle.

PROBLEM X.

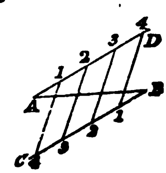
To divide a circle into 2, 4, 8, 16, or 32 equal parts.



Draw a diameter through the centre, dividing the circle into two equal parts; bisect this diameter by another, drawn perpendicular thereto, and the circle will be divided into four equal parts or quadrants; bisect each of these quadrants again by right lines drawn through the centre, and the circle will be divided into eight equal parts; and so you may continue the bisections any number of times. This problem is useful in constructing the mariner's compass.

PROBLEM XI.

To divide a given line into any number of equal parts



Let it be required to divide the line AB into five equal parts. From the point A draw any line, AD, making an angle with the line AB; then through the point B draw a line, BC, parallel to AD; and from A, with any small opening in your compasses, set off a number of equal parts on the line AD, less by one than the proposed number (which number of equal parts in this example is 4); then from B, set off the same number of the same parts on the line BC; then join 4 and 1, 3 and 2, 2 and 3, 1 and 4, and these lines will cut the given line as required.

Digitized by Google

CONSTRUCTION OF THE PLANE SCALE

1st. With the radius you intend for your scale, describe a semicircle, ADB (Plate II fig. 1), and from the centre, C, draw CD perpendicular to AB, which will divide the semicircle into two quadrants, AD, BD; continue CD towards S, draw BT perpendicular to CB, and join BD and AD.

2dly. Divide the quadrant BD into 9 equal parts; then will each of these be 10 degrees; subdivide each of these parts into single degrees, and, if your radius will admit of it, into minutes or some aliquot parts of a degree greater than minutes.

3dly. Set one foot of the compasses in B, and transfer each of the divisions of the quadrant BD to the right line BD, then will BD be a line of chords.

4thly. From the points 10, 20, 30, &c., in the quadrant BD, draw right lines parallel to CD, to cut the radius CB, and they will divide that line into a line of sines which must be numbered from C towards B.

5thly. If the same line of sines be numbered from B towards C, it will become a line of versed sines, which may be continued to 180°, if the same divisions be transferred on the same line on the other side of the centre C.

6thly. From the centre C, through the several divisions of the quadrant BD, draw right lines till they cut the tangent BT; so will the line BT become a line of tangents.

7thly. Setting one foot of the compasses in C, extend the other to the several divisions, 10, 20, 30, &c., in the tangent line, BT, and transfer these extents severally to the right line, CS; then will that line be a line of secants.

8thly. Right lines drawn from A to the several divisions, 10, 20, 30, &c., in the quadrant BD, will divide the radius CD into a line of semi-tangents.

9thly. Divide the quadrant AD into eight equal parts, and from A, as a centre, transfer these divisions severally into the line AD; then will AD be a line of rhumbs, each division answering to 11° 15′ upon the line of chords. The use of this line is for protracting and measuring angles, according to the common division of the mariner's compass. If the radius AC be divided into 100 or 1000, &c., equal parts, and the lengths of the several sines, tangents, and secants, corresponding to the several arcs of the quadrant, be measured thereby, and these numbers be set down in a table,* each in its proper column, you will by these means have a collection of numbers by which the several cases in trigonometry may be solved. Right lines, graduated as above, being placed severally upon a ruler, form the instrument called the Plane Scale (see Plate II. fig. 2), by which the lines and angles of all triangles may be measured. All right lines, as the sides of plane triangles, &c., when they are considered simply as such, without having any relation to a circle, are measured by scales of equal parts, one of which is subdivided equally into 10, and this serves as a common division to all the rest. In most scales, an inch is taken for a common measure, and what an inch is divided into is generally set at the end of the scale. By any common scale of equal parts, divided in this manner, any number less than 100 may be readily taken; but if the number should consist of three places of figures, the value of the third figure cannot be exactly ascertained, and in this case it is better to use a diagonal scale, by which any number consisting of three places of figures, may be exactly found. The figure of this scale is given in Plate II. fig. 3; its construction is as follows:—

Having prepared a ruler of convenient breadth for your scale, draw near the edges thereof two right lines, *af*, *cg*, parallel to each other; divide one of these lines, as *af* into equal parts, according to the size of your scale;† and, through each of these divisions draw right lines perpendicular to *af*, to meet *cg*; then divide the breadth into 10 equal parts, and through each of these divisions draw right lines parallel to *af* and *cg*: divide the lines *ab*, *cd*, into 10 equal parts, and from the point *a* to the first division

---

* In Table XXIV. are given the sine and cosine to every minute of the quadrant, to five places of decimals.

† The length of one of these equal parts at the end of the scale to which this description refers is *ab* or *cd*; the length of one of the equal parts of the scale of the other end being the half of *ab*

Digitized by Google

n the line *cd*, draw a diagonal line; then, parallel to that line, draw diagonal lines through all the other divisions, and the scale is complete. Then, if any number, consisting of three places of figures, as 256, be required from the larger scale, *gd*, you must place one foot of the compasses on the figure 2 on the line *gd*, then the extent from 2 to the point *d* will represent 200. The second figure being 5, count five of the smaller divisions from *d* towards *c*, and the extent from 2 to that point will be 250 Move both points of the compasses downwards till they are on the sixth parallel line below *gd*, and open them a little till the one point rests on the vertical line drawn through 2, and the other on the diagonal line drawn through 5; the extent then in the compasses will represent 256. In the same way the quantities 25.6, 2.56, 0.256, &c., are measured.

Besides the lines already mentioned, there is another on the Plane Scale, marked ML, which is joined to a line of chords, and shows how many miles of easting or westing correspond to a degree of longitude in every latitude.* These several lines are generally put on one side of a ruler two feet long; and on the other side is laid down a scale of the logarithms of the sines, tangents, and numbers, which is commonly called Gunter's Scale; and, as it is of general use, it requires a particular description.

* As it would confuse the adjoined figure to describe on it the line of longitudes, it is neglected, but the construction is as follows; divide the line CB into 60 equal parts (if it can be done), and through each point draw lines parallel to CD, to intersect the arc BD; about B, as a centre, transfer the several points of intersection to the line of chords, BD, and then number it from D towards B, from 0 to 60, and it will be the line of longitudes, corresponding to the degrees on the line of chords

GUNTER'S SCALE.

On Gunter's Scale are eight lines, viz.

1st. Sine rhumbs, marked (SR), corresponding to the logarithms* of the natural sines of every point of the mariner's compass, numbered from the left hand towards the right, with 1, 2, 3, 4, 5, 6, 7, to 8, where is a brass pin. This line is also divided, where it can be done, into halves and quarters.

2dly. Tangent rhumbs, marked (TR), correspond to the logarithms of the tangents of every point of the compass, and are numbered 1, 2, 3, to 4, at the right hand, where there is a pin, and thence towards the left hand with 5, 6, 7; it is also divided, where it can be done, into halves and quarters.

3dly. The line of numbers, marked (Num.), corresponds to the logarithms of numbers, and is marked thus: near the left hand it begins at 1, and towards the right hand are 2, 3, 4, 5, 6, 7, 8, 9; and 1 in the middle, at which is a brass pin; then 2, 3, 4, 5, 6, 7, 8, 9, and 10, at the end, where there is another pin. The values of these numbers and their intermediate divisions depend on the estimated values of the extreme numbers 1 and 10; and as this line is of great importance, a particular description of it will be given. The first 1 may be counted for 1, 10, 100, or 1000, &c., and then the next 2 will be 2, 20, 200, or 2000, &c., respectively. Again, the first 1 may be reckoned 1 tenth, 1 hundredth, or 1 thousandth part, &c.; then the next will be 2 tenth, or 2 hundredth, or 2 thousandth parts, &c.; so that if the first 1 be esteemed 1, the middle 1 will be 10; 2 to its right, 20; 3, 30; 4, 40; and 10 at the end, 100. Again, if the first 1 is 10, the next 2 is 20, 3 is 30, and so on, making the middle 1, 100; the next 2 is 200, 3 is 300, 4 is 400, and 10 at the end is 1000. In like manner, if the first 1 be esteemed 1 tenth part, the next 2 will be 2 tenth parts, and the middle 1 will be 1; the next 2, 2; and 10 at the end will be 10. Again, if the first 1 be counted 1 hundredth part; the next, 2 hundredth parts; the middle 1 will be 10 hundredth parts, or 1 tenth part: and the next 2, 2 tenth parts; and 10 at the end will be but one whole number or integer.

As the figures are increased or diminished in their value, so in like manner must all the intermediate strokes or subdivisions be increased or diminished; that is, if the first 1 at the left hand be counted 1, then 2 (next following it) will be 2, and each subdivision between them will be 1 tenth part; and so all the way to the middle 1, which will be 10; the next 2, 20; and the longer strokes between 1 and 2 are to be counted from 1 thus, 11, 12 (where is a brass pin); then 13, 14, 15, sometimes a longer stroke than the rest; then 16, 17, 18, 19, 20, at the figure 2; and in the same manner the short strokes between the figures 2 and 3, 3 and 4, 4 and 5, &c., are to be reckoned as units. Again, if 1 at the left hand be 10, the figures between it and the middle 1 will be common tens, and the subdivisions between each figure will be units; from the middle 1 to 10 at the end, each figure will be so many hundreds; and between these figures each longer division will be 10. From this description it will be easy to find the divisions representing any given number, thus: Suppose the point representing the number 12 were required; take the division at the figure 1 in the middle, for the first figure of 12; then for the second figure count two tenths, or longer strokes to the right hand, and this will be the point representing 12, where the brass pin is.

Again, suppose the number 22 were required; the first figure 2 is to be found on the scale, and for the second figure 2, count 2 tenths onwards, and that is the point representing 22.

Again, suppose 1728 were required; for the first figure 1, I take the middle 1, for the second figure 7, count onwards as before, and that will be 1700. And, as the remaining figures are 28, or nearly 30, I note the point which is nearly $\frac{3}{10}$ of the distance between the marks 7 and 8, and this will be the point representing 1728.

---

* The description and use of logarithms are given in page 28, et seq. The log. sines, tangents, &c. are marked on these scales by means of a line of equal parts, corresponding to the size of the scale.

Digitized by Google

If the point representing 435 was required, from the 4 in the second interval count towards 5 on the right, three of the larger divisions and one of the smaller (this smaller division being midway between the marks 3 and 4), and that will be the division expressing 435. In a similar manner other numbers may be found.

All fractions found in this line must be decimals; and if they are not, they must be reduced into decimals, which is easily done by extending the compasses from the denominator to the numerator; that extent laid the same way, from 1 in the middle or right hand, will reach to the decimal required.

EXAMPLE. Required the decimal fraction equal to $\frac{3}{4}$. Extend from 4 to 3; that extent will reach from 1 on the middle to .75 towards the left hand. The like may be observed of any other vulgar fraction.

Multiplication is performed on this line by extending from 1 to the multiplier; that extent will reach from the multiplicand to the product.

Suppose, for example, it were required to find the product of 16 multiplied by 4; extend from 1 to 4; that extent will reach from 16 to 64, the product required.

Division being the reverse of multiplication, therefore extend from the divisor to unity; that extent will reach from the dividend to the quotient.

Suppose 64 to be divided by 4; extend from 4 to 1; that extent will reach from 64 to 16, the quotient.

Questions in the Rule of Three are solved by this line as follows: Extend from the first term to the second; that extent will reach from the third term* to the fourth. And it ought to be particularly noted, that if you extend to the left, from the first number to the second, you must also extend to the left, from the third number to the fourth; and the contrary.

EXAMPLE. If the diameter of a circle be 7 inches, and the circumference 22, what is the circumference of another circle, the diameter of which is 14 inches? Extend from 7 to 22; that extent will reach from 14 to 44, the same way.

The superficial content of any parallelogram is found by extending from 1 to the breadth; that extent will reach from the length to the superficial content.

EXAMPLE. Suppose a plank or board to be 15 inches broad and 27 feet long, the content of which is required. Extend from 1 to 1 foot 3 inches (or 1.25); that extent will reach from 27 feet to 33.75 feet, the superficial content. Or extend from 12 inches to 15, &c.

The solid content of any bale, box, chest, &c., is found by extending from 1 to the breadth; that extent will reach from the depth to a fourth number, and the extent from 1 to that fourth number will reach from the length to the solid content.

EXAMPLE I. What is the content of a square pillar, whose length is 21 feet 9 inches, and breadth 1 foot 3 inches? The extent from 1 to 1.25 will reach from 1.25 to 1.56, the content of one foot in length; again, the extent from 1 to 1.56, will reach from the length 21.75 to 33.9, or 34, the solid content in feet.

EXAMPLE II. Suppose a square piece of timber, 1.25 feet broad, .56 deep, and 36 long, be given to find the content. Extend from 1 to 1.25; that extent will reach from .56 to .7; then extend from 1 to .7; that extent will reach from 36 to 25.2, the solid content. In like manner may the contents of bales, &c., be found, which, being divided by 40, will give the number of tons.

4thly. The line of sines, marked (Sin.), corresponding to the log. sines of the degrees of the quadrant, begins at the left hand, and is numbered to the right, 1, 2, 3, 4, 5, &c., to 10; then 20, 30, 40, &c., ending at 90 degrees, where is a brass centre-pin, as there is at the right end of all the lines.

5thly. The line of versed sines, marked (V. S.), corresponding to the log. versed sines of the degrees of the quadrant, begins at the right hand against 90° on the sines, and from thence is numbered towards the left hand, 10, 20, 30, 40, &c., ending at the left hand at about 169°; each of the subdivisions, from 10 to 30, is in general two degrees; from thence to 90 is single degrees; from thence to the end, each degree is divided into 15 minutes.

6thly. The line of tangents, marked (Tang.), corresponding to the log. tangents of the degrees of the quadrant, begins at the left hand, and is numbered towards the right, 1, 2, 3, &c. to 10, and so on, 20, 30, 40, and 45, where is a brass pin under 90° on the sines; from thence it is numbered backwards, 50, 60, 70, 80, &c. to 89, ending at the left hand where it began at 1 degree. The subdivisions are nearly similar to those of the sines. When you have any extent in your compasses, to be set off from any number less than 45° on the line of tangents, towards the right, and it is found to reach

* Or you may extend from the first to the third; for that extent will reach from the second to the fourth. This method must be adopted when using the lines of sines, tangents, &c., if the first and third terms are of the same name, and different from the second and fourth.

Digitized by Google

beyond the mark of 45°, you must see how far it extends beyond that mark, and set it off from 45° towards the left, and see what degree it falls upon, which will be the number sought, which must exceed 45°; if, on the contrary, you are to set off such a distance to the right from a number greater than 45°, you must proceed as before, only remembering, that the answer must be less than 45°, and you must always consider the degrees above 45°, as if they were marked on the continuation of the line to the right hand of 45°.

7thly. The line of the meridional parts, marked (Mer.), begins at the right hand, and is numbered, 10, 20, 30, &c., to the left hand, where it ends at 87 degrees. This line, with the line of equal parts, marked (E. P.), under it, are used together, and only in Mercator's Sailing. The upper line contains the degrees of the meridian, or latitude in a Mercator's chart, corresponding to the degrees of longitude on the lower line.

The use of this Scale in solving the usual problems of Trigonometry, Plane Sailing, Middle Latitude Sailing, and Mercator's Sailing, will be given in the course of this work; but it will be unnecessary to enter into an explanation of its use in calculating the common problems of Nautical Astronomy as it is much more accurate to perform those calculations by logarithms.

Digitized by Google

ON THE SLIDING RULE.

The Sliding Rule consists of a *fixed part* and a *slider*, and is of the same dimensions, and has the same lines marked on it as on a common Gunter's Scale or Plane Scale, which may be used, with a pair of compasses, in the same manner as those scales; and as a description of those lines has already been given, it will be unnecessary to repeat it here, it being sufficient to observe, that there are two lines of numbers, a line of log. sines, and a line of log. tangents, on the slider, and that it may be shifted so as to fix any face of it on either side of the fixed part of the scale, according to the nature of the question to be solved.

In solving any problem in Arithmetic, Trigonometry, Plane Sailing, &c., let the proposition be so stated that the first and third terms may be alike, and of course the second and fourth terms alike; then *bring the first term of the analogy on the fixed part, against the second term on the slider, and against the third term on the fixed part will be found the fourth term on the slider;* * or, if necessary, the first and third terms may be found on the slider, and the second and fourth on the fixed part. Multiplication and division are performed by this rule, in considering unity as one of the terms of the analogy.

Thus, to perform multiplication; set 1 on the line of numbers of the fixed part, against one of the factors on the line of numbers of the slider; then against the other factor, on the fixed part, will be found the product on the slider.

Example. To find the product of 4 by 12; draw out the slider till 1 on the fixed part coincides with 4 on the slider; then opposite 12 on the fixed part will be found 48 on the slider.

To perform division; set the divisor on the line of numbers of the fixed part against 1 on the slider; then against the dividend on the fixed part will be found the quotient on the slider.

Example. To divide 48 by 4; set 4 on the fixed part against 1 on the slider; then against 48 on the fixed part will be found 12 on the slider.

EXAMPLES IN THE RULE OF THREE.

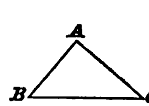
If a ship sail 25 miles in 4 hours, how many miles will she sail in 12 hours at the same rate?

Bring 4 on the line of numbers of the fixed part against 25 on the line of numbers of the slider; then against 12 on the fixed part will be found 75 on the slider, which is the answer required.

Example. If 3 pounds of sugar cost 21 cents, what will 27 pounds cost?

Bring 3 on the line of numbers of the fixed part, against 21 on the line of numbers of the slider; then against 27 on the fixed part will be found 189 on the slider.

EXAMPLE IN TRIGONOMETRY.



In the oblique-angled triangle ABC, let there be given AB = 56, AC = 64, angle ABC = 46° 30′, to find the other angles and the side BC.

In this case we have (by *Art.* 58, Geometry) the following canons:—

AC (64) : sine angle B (46° 30′) :: AB (56) : sine angle C; and sine angle B : AC :: sine angle A : BC. Therefore, to work the first proportion by the sliding rule, we must bring 64 on the line of numbers of the fixed part against 46° 30′ on the line of sines of the slider; then against 56 on the former will be 39° 24′ on the latter, which will be

* If the first and second terms are alike, instead of the first and third, you must bring the first term on the slider against the third on the fixed part, and against the second term on the slider will be found the fourth term on the fixed part; or, if necessary, the first and second terms may be found on the fixed part, and the third and fourth on the slider

Digitized by Google

the angle C. The sum of the angles B and C, being subtracted from 180°, leaves the angle A = 94° 6′. Then, by the second canon, bring the angle B = 46° 30′, on the line of sines of the slider against AC = 64, on the line of numbers of the fixed part; then against the angle A = 94° 6′ (or its supplement, 85° 54′) on the slider will be found the side BC = 88 on the fixed part.

In a similar manner may the other propositions in Trigonometry be solved.

From what has been said, it will be easy to work all the problems in Plane, Middle Latitude, and Mercator's Sailing, as in the three following examples, which the learner may pass over until he can solve the same problems by the scale. If any one wishes to know the use of the Sliding Rule in problems of Spherical Trigonometry, he may consult the treatises written expressly on that subject; but it may be observed, that in such calculations the Sliding Rule is rather an object of curiosity than of real use, as it is much more accurate to make use of logarithms.

Example I. Given the course sailed 1 point, and the distance 85 miles; required the difference of latitude and departure.

By Case I. of Plane Sailing, we have these canons:—

Radius (8 points): Distance (85) :: Sine Co. Course (7 points) : Difference of Latitude and Radius (8 points) : Distance (85) :: Sine Course (1 point) : Departure.

Hence we must bring the radius, 8 points, on the fixed part of the sine rhumbs against 85 on the line of numbers on the slider; then against 7 points on the sine rhumbs will be found the difference of latitude, 83½, on the slider, and against 1 point will be found the departure, 16½ miles.

If the course is given in degrees, you must use the line marked (Sin.)

Example II. Given the difference of latitude, 40 miles, and departure, 30 miles required the course and distance.

By Case VI. of Plane Sailing, we have this canon for the course:—

Difference of Latitude (40) : Radius (45°) :: Departure (30) : Tangent Course.

Hence we must bring 40 on the line of numbers of the slider against 45° on the line of tangents on the fixed part; then against 30 on the slider will be found the course, 37°, nearly.

Again, the canon for the distance gives

Sine Course (37°) : Departure (30) :: Radius (90°) : Distance.

Hence we must bring 37° on the line of sines of the fixed part against 30 on the line of numbers on the slider; then against 90° on the line of sines of the fixed part will be found the distance, 50, on the slider.

Example III Given the middle latitude, 40°, and the departure, 30 miles; required he difference of longitude.

By Case VI. of Middle Latitude Sailing, we have this canon:—

Sine Comp. Middle Latitude (50°) : Departure (30) :: Radius (90°) : Difference Long

Hence by bringing 50°, on the line of sines of the fixed part, against 30 on the line of numbers on the slider, then against 90° on the fixed part we shall find 39 on the slider, which will be the difference of longitude required.

Digitized by Google

DESCRIPTION AND USE OF THE SECTOR

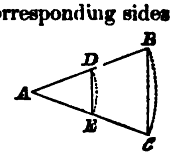
This instrument consists of two rules or legs, movable round an axis or joint, as a centre, having several scales drawn on the faces, some single, others double; the single scales are like those upon a common Gunter's Scale; the double scales are those which proceed from the centre, each being laid twice on the same face of the instrument, viz. once on each leg. From these scales, dimensions or distances are to be taken, when the legs of the instrument are set in an angular position.

The single scales being used exactly like those on the common Gunter's Scale, it is unnecessary to notice them particularly; we shall therefore only mention a few of the uses of the double scales, the number of which is seven, viz. the scale of Lines, marked Lin. or L.; the scale of Chords, marked Cho. or C.; the scale of Sines, marked Sin. or S.; the scale of Tangents to 45°, and another scale of Tangents, from 45° to about 76°, both of which are marked Tan. or T.; the scale of Secants, marked Sec. or S.; and the scale of Polygons, marked Pol.

The scales of lines, chords, sines, and tangents under 45°, are all of the same radius, beginning at the centre of the instrument, and terminating near the other extremity of each leg, viz. the lines at the division 10, the chords at 60°, the sines at 90°, and the tangents at 45°; the remainder of the tangents, or those above 45°, are on other scales, beginning at a quarter of the length of the former, counted from the centre, where they are marked with 45°, and extend to about 76 degrees. The secants also begin at the same distance from the centre, where they are marked with 0, and are from thence continued to 75°. The scales of polygons are set near the inner edge of the legs, and where these scales begin, they are marked with 4, and from thence are numbered backward or towards the centre, to 12.

In describing the use of the Sector, the terms *lateral distance* and *transverse distance* often occur. By the former is meant the distance taken with the compasses on one of the scales only, beginning at the centre of the sector; and by the latter, the distance taken between any two corresponding divisions of the scales of the same name, the legs of the sector being in an angular position.

The use of the Sector depends upon the proportionality of the corresponding sides of similar triangles (demonstrated in *Art.* 53, Geometry). For if, in the triangle ABC, we take AB = AC, and AD = AE, and draw DE, BC, it is evident that DE and BC will be parallel; therefore, by the above-mentioned proposition, AB : BC :: AD : DE; so that, whatever part AD is of AB, the same part DE will be of BC; hence, if DE be the chord, sine, or tangent, of any arc to the radius AD, BC will be the same to the radius AB.



Use of the line of Lines.

The line of lines is useful to divide a given line into any number of equal parts, or in any proportion, or to find third and fourth proportionals, or mean proportionals, or to increase a given line in any proportion.

Example I. To divide a given line into any number of equal parts, as suppose 9, make the length of the given line a transverse distance to 9 and 9, the number of parts proposed; then will the transverse distance of 1 and 1 be one of the parts, or the ninth part of the whole; and the transverse distance of 2 and 2 will be two of the equal parts, or $\frac{2}{9}$ of the whole line, &c.

Example II. If a ship sails 52 miles in 8 hours, how much would she sail in 3 hours at the same rate?

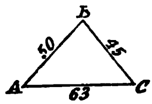
Take 52 in your compasses as a transverse distance, and set it off from 8 to 8; then the transverse distance, 3 and 3, being measured laterally, will be found equal to 19 and a half, which is the number of miles required.

EXAMPLE III. Having a chart constructed upon a scale of 6 miles to an inch, it is required to open the Sector, so that a corresponding scale may be taken from the line of lines.

Make the transverse distance, 6 and 6, equal to 1 inch, and this position of the sector will produce the given scale.

EXAMPLE IV. It is required to reduce a scale of 6 inches to a degree to another of 3 inches to a degree.

Make the transverse distance, 6 and 6, equal to the lateral distance, 3 and 3; then set off any distance from the chart laterally, and the corresponding transverse distance will be the reduced distance required.



EXAMPLE V. One side of any triangle being given, of any length, to measure the other two sides on the same scale.

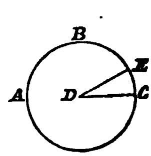
Suppose the side AB of the triangle ABC measures 50, what are the measures of the other two sides?

Take AB in your compasses, and apply it transversely to 50 and 50; to this opening of the Sector apply the distance AC, in your compasses, to the same number on both sides of the rule transversely; and where the two points fall will be the measure on the line of lines of the distance required; the distance AC will fall against 63, 63, and BC against 45, 45, on the line of lines.

Use of the line of Chords on the Sector.

The line of chords upon the Sector is very useful for protracting any angle, when the paper is so small that an arc cannot be drawn upon it with the radius of a common line of chords.

Suppose it was required to set off an arc of 30° from the point C of the small circle ABC, whose centre is D.



Take the radius, DC, in your compasses, and set it off transversely from 60° to 60° on the chords; then take the transverse extent from 30° to 30° on the chords, and place one foot of the compasses in C; the other will reach to E, and CE will be the arc required. And by the converse operation, any angle or arc may be measured, viz. with any radius describe an arc about the angular point; set that radius transversely from 60° to 60°; then take the distance of the arc, intercepted between the two legs, and apply it transversely to the chords, which will show the degrees of the given angle.

Note. When the angle to be protracted exceeds 60°, you must lay off 60°, and then the remaining part; or if it be above 120°, lay off 60° twice, and then the remaining part. And in a similar manner any arc above 60° may be measured.

Uses of the lines of Sines, Tangents, and Secants.

By the several lines disposed on the Sector, we have scales of several radii; so that,

1st. Having a length or radius given, not exceeding the length of the Sector when opened, we can find the chord, sine, &c. of an arc to that radius; thus, suppose the chord, sine, or tangent of 20 degrees to a radius of 2 inches be required. Make 2 inches the transverse opening to 60° and 60° on the chords; then will the same extent reach from 45° to 45° on the tangents, and from 90° to 90° on the sines; so that, to whatever radius the lines of chords is set, to the same are all the others set also. In this disposition, therefore, if the transverse distance between 20° and 20° on the chords be taken with the compass, it will give the chord of 20 degrees; and if the transverse of 20° and 20° be in like manner taken on the sines, it will be the sine of 20 degrees and lastly, if the transverse distance of 20° and 20° be taken on the tangents, it will be the tangent of 20 degrees to the same radius of two inches.

2dly. If the chord or tangent of 70° were required. For the chord you must first set off the chord of 60° (or the radius) upon the arc, and then set off the chord of 10°. To find the tangent of 70 degrees, to the same radius, the scale of upper tangents must be used, the under one only reaching to 45°; making therefore 2 inches the transverse distance to 45° and 45° at the beginning of that scale, the extent between 70° and 70° on the same will be the tangent of 70 degrees to 2 inches radius.

3dly. To find the secant of any arc; make the given radius the transverse distance between 0 and 0 on the secants; then will the transverse distance of 20° and 20°, or 70° and 70°, give the secant of 20° or 70° respectively.

Digitized by Google

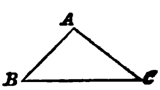
4thly. If the radius and any line representing a sine, tangent, or secant, be given, the degrees corresponding to that line may be found by setting the Sector to the given radius, according as a sine, tangent, or secant, is concerned; then, taking the given line between the compasses, and applying the two feet transversely to the proper scale, and sliding the feet along till they both rest on like divisions on both legs, then the divisions will show the degrees and parts corresponding to the given line.

Use of the line of Polygons.

The use of this line is to inscribe a regular polygon in a circle. For example, let it be required to inscribe an octagon or polygon of eight equal sides, in a circle. Open the Sector till the transverse distance 6 and 6 be equal to the radius of the circle; then will the transverse distance of 8 and 8 be the side of the inscribed polygon.

Use of the Sector in Trigonometry.

All proportions in Trigonometry are easily worked by the double lines on the Sector; observing that the sides of triangles are taken upon the line of lines, and the angles are taken upon the sines, tangents, or secants, according to the nature of the proportion. Thus, if, in the triangle ABC, we have given AB = 56, AC = 64, and the angle ABC = 46° 30′, to find the rest; in this case we have (by *Art.* 58, Geometry) the following proportions; As AC (64) : sine angle B (46° 30′) :: AB (56) : sine angle C; and as sine B : AC :: sine A : BC. Therefore, to work these proportions by the Sector, take the lateral distance, 64 = AC, from the line of lines, and open the Sector to make this a transverse distance of 46° 30′ = angle B on the sines; then take the lateral distance 56 = AB on the lines, and apply it transversely on the sines, which will give 39° 24′ = angle C. Hence the sum of the angles B and C is 85° 54′, which taken from 180°, leaves the angle A = 94° 6′. Then, to work this second proportion, the Sector being set at the same opening as before, take the transverse distance of 94° 6′ = the angle A on the sines, or, which is the same thing, the transverse distance of its supplement, 85° 54′; then this, applied laterally to the lines, gives the sought side, BC = 88. In the same manner we might solve any problem in Trigonometry, where the tangents and secants occur, by only measuring the transverse distances on the tangents or secants, instead of measuring them on the sines, as in the preceding example. All the problems that occur in Nautical Astronomy may be solved by the sector; but as the calculation by logarithms is much more accurate it will be useless to enter into a further detail on this subject



Digitized by Google

LOGARITHMS.

In order to abbreviate the tedious operations of multiplication and division with large numbers, a series of numbers, called Logarithms, was invented by Lord Napier, Baron of Marchiston in Scotland, and published in Edinburgh in 1614; by means of which the operation of multiplication may be performed by addition, and division by subtraction; numbers may be involved to any power by simple multiplication, and the root of any power extracted by simple division.

In Table XXVI. are given the logarithms of all numbers from 1 to 9999; to each one must be prefixed an index, with a period or dot to separate it from the other part, as in decimal fractions; the numbers from 1 to 100 are published in that table with their indices; but from 100 to 9999 the index is left out for the sake of brevity; but it may be supplied by this general rule, viz. *The index of the logarithm of any integer or mixed number is always one less than the number of integral places in the natural number.* Thus the index of the logarithm of any number (integral or mixed), between 10 and 100, is 1; from 100 to 1000, it is 2; from 1000 to 10000 is 3, &c.; the method of finding the logarithms from this table will be evident from the following examples.

To find the logarithm of any number less than 100.

Rule. Enter the first page of the table, and opposite the given number will be found the logarithm with its index prefixed.

Thus opposite 71 is 1.851126, which is its logarithm

To find the logarithm of any number between 100 *and* 1000.

Rule. Find the given number in the left-hand column of the table of logarithms, and immediately under 0 in the next column is a number, to which must be prefixed the number 2 as an index (because the number consists of three places of figures) and you will have the sought logarithm.

Thus, if the logarithm of 149 was required; this number being found in the left-hand column, against it, in the column marked 0 at the top (or bottom), is found 17319 to which prefixing the index 2, we have the logarithm of 149 = 2.17319.

To find the logarithm of any number between 1000 *and* 10000.

Rule. Find the three left-hand figures of the given number, in the left-hand column of the table of logarithms, opposite to which, in the column that is marked at the top (or bottom) with the fourth figure, is to be found the sought logarithm; to which must be prefixed the index 3, because the number contains four places of figures.

Thus, if the logarithm of 1495 was required; opposite to 149, and in the column marked 5 at the top (or bottom), is 17464, to which prefix the index 3, and we have the sought logarithm, 3.17464.

To find the logarithm of any number above 10000.

Rule. Find the three first figures of the given number in the left-hand column of the table, and the fourth figure at the top or bottom, and take out the corresponding number as in the preceding rule; take also the difference between this logarithm and the next greater, and multiply it by the given number exclusive of the four first figures; cross off at the right hand of the product as many figures as you had figures of the given number to multiply by; then add the remaining left-hand figures of this product to the logarithm taken from the table, and to the sum prefix an index equal to one less

Digitized by Google

than the number of integral figures in the given number, and you will have the sought logarithm. To facilitate the calculation of these proportional parts, several small tables are placed in the margin, which give the correction corresponding to the difference D, and to the *fifth* figure of the proposed number. The use of these tables will be seen in the following examples.

Thus, if the logarithm of 14957 was required; opposite to 149, and under 5, is 17464, the difference between this and the next greater number, 17493, is 29, the difference D; this multiplied by 7 (the last figure of the given number) gives 203; crossing off the right-hand figure leaves 20.3 or 20 to be added to 17464, which makes 17484; to this prefixing the index 4, we have the sought logarithm, 4.17484. This correction, 20 may also be found by inspection in the small table in the margin, marked at the top with D = 29, and opposite to the *fifth* figure of the number, namely 7, at the side; the corresponding number is the correction, 20.

Again, if the logarithm of 1495738 was required; the logarithm corresponding to 149 at the left, and 5 at the top, is, as in the last example, 17464; the difference between this and the next greater is 29; multiplying this by 738 (which is equal to the given number, excluding the four first figures) gives 21402; crossing off the three right-hand figures of this product (because the number 738 consists of three figures), we have the correction 21 to be added to 17464; and the index to be prefixed is 6, because the given number consists of 7 places of figures; therefore the sought logarithm is 6.17485. This correction, 21, may be found as above, by means of the marginal table, marked at the top with D = 29, and at the side 7.38 or 7½ nearly, to which corresponds 21, as before.

To find the logarithm of any mixed decimal number.

RULE. Find the logarithm of the number, as if it was an integer, by the last rule, to which prefix the index of the integral part of the given number.

Thus, if the logarithm of the mixed decimal 149.5738 was required; find the logarithm of 1495738, without noticing the decimal point; this, in the last example, was found to be 17485; to this we must prefix the index 2, corresponding to the integral part 149; the logarithm sought will therefore be 2.17485.

To find the logarithm of any decimal fraction less than unity.

The index of the logarithm of any number less than unity is negative; but to avoid the mixture of positive and negative quantities, it is common to borrow 10 or 100 in the index, which must afterwards be neglected in summing them with other indices thus, instead of writing the index −1, it is usually written +9, or +99; but in general it is sufficient to borrow 10 in the index; *and it is what we shall do in the rest of this work.* In this way we may find the logarithm of any decimal fraction by the following rule.

RULE. Find the logarithm of a fraction as if it was a whole number; see how many ciphers precede the first figure of the decimal fraction, subtract that number from 9, and the remainder will be the index of the given fraction.

Thus the logarithm of 0,0391 is 8.59218; the logarithm of 0.25 is 9.39794; the logarithm of 0.0000025 is 4.39794, &c.

To find the logarithm of a vulgar fraction.

RULE. Subtract the logarithm of the denominator from the logarithm of the numerator (borrowing 10 in the index when the denominator is the greatest); the remainder will be the logarithm of the fraction sought.

EXAMPLE I.

Required the logarithm of ⅜.

From log. of 3	0.47712
Take log. of 8	0.90309
Remainder, log. of ⅜ or .375....	9.57403

EXAMPLE II.

Required the logarithm of 3¼, or $\frac{13}{4}$.

From log. of 13................	1.11394
Take log. of 4................	0.60206
Remainder, log. of 3¼ or 3.25...	0.51188

To find the number corresponding to any logarithm.

RULE. In the column marked 0 at the top (and bottom) of the table, seek for the next less logarithm, neglecting the index; note the number against it, and carry your eye

Digitized by Google

along that line until you find the nearest less logarithm to the given one, and you will have the fourth figure of the given number at the top, which is to be placed to the right of the three other figures; if you wish for greater accuracy, you must take the difference, D, between this tabular logarithm and the next greater, also the difference, *d*, between that least tabular logarithm and the given one; to the latter difference, *d*, annex two or more ciphers at the right hand, and divide it by the former difference, D, and place the quotient* to the right hand of the four figures already found, and you will have the number sought, expressed in a mixed decimal, the integral part of which will consist of a number of figures (at the left hand) equal to the index of the logarithm increased by unity.†

Thus, if the number corresponding to the logarithm 1.52634 was required, we find 52634 in the column marked 0 at the top or bottom, and opposite to it is 336; now, the index being 1, the sought number must consist of two integral places; therefore it is 33.6.

If the given logarithm was 2.32838, we find that 32838 stands in the column marked 0 at the top or bottom, directly opposite to 213, which is the number sought, because, the index being 2, the number must consist of three places of figures.

If the number corresponding to the logarithm 2.57345 was required, we must look in the column 0; and we find in it, against the number 374, the logarithm 57287; and, guiding the eye along that line, we find the given logarithm, 57345, in the column marked 5; therefore the mixed number sought is 3745; and, since the index is 2, the integral part must consist of 3 places; therefore the number sought is 374.5. If the index be 1, the number will be 37.45; and if the index be 0, the number will be 3.745. If the index be 8, corresponding to a number less than unity, the answer will be 0.03745, &c.

Again, if the number corresponding to the logarithm 5.57811 was required, look in the column 0, and find in it, against 378, and under 5, the logarithm 57807, the difference between this and the next greater logarithm, 57818, being 11, and the difference between 57807 and the given number, 57811, being 4; to this 4 affix two ciphers, which make 400, and divide it by 11; the quotient is 36 nearly; this number, being connected with the former four figures, makes 378536, which is the number required, since, the index being 5, the number must consist of six places of figures.

To show, at one view, the indices corresponding to mixed and decimal numbers, we have given the following table.

Mixed number.	*Logarithms.*	*Decimal number.*	*Logarithms.*
40943.0..........	Log. 4.61218	0.40943..........	Log. 9.61218
4094.3..........	Log. 3.61218	0.040943.........	Log. 8.61218
409.43.........	Log. 2.61218	0.0040943........	Log. 7.61218
40.943........	Log. 1.61218	0.00040943......	Log. 6.61218
4.0943.......	Log. 0.61218	0.000040943......	Log. 5.61218

MULTIPLICATION BY LOGARITHMS.

Rule. Add the logarithms of the two numbers to be multiplied, and the sum will be the logarithm of their product.

EXAMPLE I.		EXAMPLE II.	
Multiply 25 by 35.		Multiply 22.4 by 1.8.	
25.............	Log. 1.39794	22.4	Log. 1.35025
35.............	Log. 1.54407	1.8	Log. 0.25527
Product, 875.............	Log. 2.94201	Product, 40.32............	Log. 1.60552

* This quotient must consist of as many places of figures as there were ciphers annexed, conformable to the rules of the division of decimals. Thus, if the divisor was 40, and the number to which two ciphers were annexed was 2, making 2.00, the quotient must not be estimated as 5, but as 05, and then two figures must be placed to the right of the four figures before found.

† If the index corresponds to a fraction less than unity, you must place as many ciphers to the left of that number as are equal to the index subtracted from 9, the decimal point being placed to the left of these ciphers; in this manner you will obtain the sought number.

We may find the fifth figure of the required number by means of the marginal tables, by entering the table corresponding at the top to the proposed value of D, and in the right-hand column with *d*; the corresponding number is the fifth figure of the required natural number.

Digitized by Google

EXAMPLE III.

Multiply 3.26 by 0.0025.

3.26............Log. 0.51322
0.0025...........Log. 7.39794

Product, 0.00815..........Log. 7.91116

EXAMPLE IV.

Multiply 0.25 by 0.003.

0.25.............Log. 9.39794
0.003............Log. 7.47712

Product, 0.00075..........Log. 6.87506

In the last example, the sum of the two indices is 16; but since 10 was borrowed in each number, we have neglected 10 in the sum; and the remainder, 6, being less than the other 10, is evidently the index of the logarithm of a fraction less than unity.

DIVISION BY LOGARITHMS.

Rule. From the logarithm of the dividend subtract the logarithm of the divisor the remainder will be the logarithm of the quotient.

EXAMPLE I.

Divide 875 by 25.

875.............Log. 2.94201
25.............Log. 1.39794

Quotient, 35.............Log. 1.54407

EXAMPLE II.

Divide 40.32 by 22.4.

40.32 ....Log. 1.60552
22.4 ....Log. 1.35025

Quotient, 1.8 ....Log. 0.25527

EXAMPLE III.

Divide 0.00815 by 0.0025.

0.00815 ....Log. 7.91116
0.0025 ....Log. 7.39794

Quotient, 3.26 ....Log. 0.51322

EXAMPLE IV.

Divide 0.00075 by 0.025.

0.00075 ....Log. 6.87506
0.025 ....Log. 8.39794

Quotient, 0.03 ....Log. 8.47712

In Example III. both the divisor and dividend are fractions less than unity, and the divisor is the least; consequently the quotient is greater than unity. In Example IV. both fractions are less than unity; and, since the divisor is the greatest, its logarithm is greater than that of the dividend; for this reason it is necessary to borrow 10 in the index before making the subtraction; hence the quotient is less than unity.

INVOLUTION BY LOGARITHMS.

Rule. Multiply the logarithm of the number given, by the index of the power to which the quantity is to be raised; the product will be the logarithm of the power sought. But in raising the powers of any decimal fraction, it must be observed, that the first significant figure of the power must be put as many places below the place of units as the index of its logarithm wants of 10 multiplied by the index of the power

EXAMPLE I.

Required the square of 18.

18 ....Log. 1.25527
2

Answer, 324 ....Log. 2.51054

EXAMPLE II.

Required the cube of 13.

13 ....Log. 1.11394
3

Answer, 2197 ....Log. 3.34182

EXAMPLE III.

Required the square of 6.4.

6.4.............Log. 0.80618
2

Answer, 40.96............Log. 1.61236

EXAMPLE IV.

Required the cube of 0.25.

0.25...........Log. 9.39794
3

Answer, 0.015625.... .Log. 28.19382

In the last example, the index 28 wants 2 of 30 (the product of 10 by the power 3); therefore the first significant figure of the answer, viz. 1, is placed two figures distant from the place of units

Digitized by Google

EVOLUTION BY LOGARITHMS.

RULE. Divide the logarithm of the number by the index of the power; the quotient will be the logarithm of the root sought. But if the power whose root is to be extracted is a decimal fraction less than unity, prefix to the index of its logarithm a figure less by one than the index of the power,* and divide the whole by the index of the power: the quotient will be the logarithm of the root sought.

EXAMPLE I.

What is the square root of 324?

324	Log. 2)	2.51055
Answer, 18	Log.	1.25527

EXAMPLE II.

Required the cube root of 2197.

2197	Log. 3)	3.34183
Answer, 13	Log.	1.11394

EXAMPLE III.

Required the square root of 40.96.

40.96	Log. 2)	1.61236
Answer, 6.4	Log.	0.80618

EXAMPLE IV.

Required the cube root of 0.015625.

0.015625	Log.	8.19382
Prefix 2 to the index	3)	28.19382
Answer, 0.25	Log.	9.39794

TO WORK THE RULE OF THREE BY LOGARITHMS.

When three numbers are given to find a fourth proportional, in arithmetic, we make a statement, and say, As the first number is to the second, so is the third to the fourth; and by multiplying the second and third together, and dividing the product by the first, we obtain the fourth number sought. To obtain the same result by logarithms, we must *add the logarithms of the second and third numbers together, and from the sum subtract the logarithm of the first number; the remainder will be the logarithm of the sought fourth number.*

EXAMPLE I.

If 6 yards of cloth cost 5 dollars, what will 20 yards cost?

As 6	Log.	0.77815
Is to 5	Log.	0.69897
So is 20	Log.	1.30103
Sum of 2d and 3d		2.00000
Subtract the first		0.77815
To 16.67	Log.	1.22185

The answer, therefore, is 16 dollars and $\frac{67}{100}$, or 16 dollars and 67 cents.

EXAMPLE II.

If a ship sails 20 miles in 7 hours, how much will she sail in 21 hours at the same rate?

As 7	Log.	0.84510
Is to 20	Log.	1.30103
So is 21	Log.	1.32222
Sum of 2d and 3d		2.62325
Subtract the first		0.84510
To 60	Log.	1.77815

The answer is 60 miles.

TO CALCULATE COMPOUND INTEREST BY LOGARITHMS.

To 100 dollars add its interest for one year; find the logarithm of this sum, and reject 2 in the index; then multiply it by the number of years and parts of a year for which the interest is to be calculated; to the product add the logarithm of the sum put at interest; the sum of these two logarithms will be the logarithm of the amount of the given sum for the given time.

* In this rule it is supposed that 10 is borrowed in finding the index to the decimal according to the rule, page 29.

Digitized by Google

EXAMPLE.

Required the amount of the principal and interest of 355 dollars, let at 6 per cent. compound interest, for 7 years.

Adding 6 to 100 gives 106; whose logarithm, rejecting 2 in the index, is	0.02531
Multiplied by	7
Product	0.17717
Principal, 355 dollars ....Log.	2.55023
Sum gives the logarithm of 533.83 ....Log.	2.72740

Therefore the amount of principal and interest is 533 dollars and 83 cents.

To find the logarithm of the sine, tangent, or secant, corresponding to any number of degrees and minutes, by Table XXVII.

The given number of degrees must be found at the bottom of the page when between 45° and 135°, otherwise at the top; the minutes being found in the column marked M, which stands on the side of the page on which the degrees are marked; thus, *if the degrees are less than* 45, *the minutes are to be found in the left-hand column*, &c.; *and it must be noted that if the degrees are found at the top, the names of* hour, sine, cosine, tangent, &c., *must also be found at the top; and if the degrees are found at the bottom, the names* sine, cosine, &c., *must also be found at the bottom.* Then opposite to the number of the minutes will be found the log. sine, log. secant, &c. in the columns marked *sine*, *secant*, &c. respectively.

EXAMPLE I.

Required the log. sine of 28° 37′.

Find 28° at the top of the page, directly below which, in the left-hand column, find 37′; against which, in the column marked *sine*, is 9.68029, the log. sine of the given number of degrees; and in the same manner the tangents, &c. are found.

EXAMPLE II.

Required the log. secant of 126° 20′.

Find 126° at the bottom of the page, directly above which, in the left-hand column, find 20′; against which, in the column marked *secant*, is 10.22732 required.

To find the logarithm of the sine, cosine, &c. for degrees, minutes, and seconds, by Table XXVII.

Find the numbers corresponding to the even minutes next above and below the given degrees and minutes, and take their difference, D; then say, As 60″ is to the number of seconds in the proposed number, so is that difference, D, to a correction, *d*, to be applied to the number corresponding to the least number of degrees and minutes; additive if it is the least of the two numbers taken from the table, otherwise subtractive.

EXAMPLE III.

Required the log. sine of 24° 16′ 38″.

Sine of 24° 16′ ....Log.	9.61382
Sine of 24 17 ....Log.	9.61411
Difference.. ...D =	29

Then, as 60″ : 38″ :: 29 : 18, which, being added to the number corresponding to 24° 16′, gives 9.61400, the log. sine of 24° 16′ 38″.

EXAMPLE IV.

Required the log. secant of 105° 20′ 16″.

Secant of 105° 20′ ....Log.	10.57768
Secant of 105 21 ....Log.	10.57722
Difference......D =	46

Then, as 60″ : 16″ :: 46 : 12, which, being subtracted from the number corresponding to 105° 20′, gives 10.57756, the log. secant of 105° 20′ 16″.

If the given seconds be $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, or $\frac{1}{6}$, or any other even parts of a minute, the like parts may be taken of the difference of the logarithms, and added or subtracted as above, which may be frequently done by inspection. These proportional parts may also be found very nearly by means of the three columns of differences for seconds, given, for the first time, in the ninth edition of this work. The first column of differences, which is to be used with the two columns marked A, A, is placed between

Digitized by Google

these columns. The second column of differences, which is to be used with the two columns B, B, is placed between these two columns. In like manner, the third column of differences, between the columns C, C, is to be used with them. The correction of the tabular logarithms in any of the columns A, B, C, for any number of seconds, is found by entering the left-hand column of the table, *marked* S′ *at the top*, and finding the number of seconds; opposite to this, in the column of differences, will be found the corresponding correction. Thus, in the table, page 215, which contains the log. sines, tangents, &c., for 30°, the corrections corresponding to 25″, are 9 for the columns A, A, 12 for the columns B, B, 3 for the columns C, C; so that, if it were required to find the sine, tangent, or secant of 30° 12′ 25″ we must add these corrections respectively to the numbers corresponding to 30° 12′; thus,

	Col. A.		Col. B.		Col. C
Logs. for 30° 12′....Sine	9.70159	Tangent....	9.76493	Secant....	10.06335
Corrections for 25″ in S′	+9		+12		+3
Logs. for 30° 12′ 25″....	9.70168		9.76505		10.06338

these corrections being all added, because the logarithms increase in proceeding from 30° 12′ to 30° 13′. Instead of taking out the logarithms for 30° 12′, and adding the correction for 25″, we may take out the logarithms for 30° 13′, and subtract the correction for 60″ — 25″, or 35″, found in the margin S′; thus,

Logs. for 30° 13′....Sine	9.70180	Tangent....	9.76522	Secant....	10.06342
Corr. for 35″ in col. S′, or 25″ in col. G′	—13		—17		—4
Logs. for 30° 12′ 25″....	9.70167		9.76505		10.06338

The corrections are in this case subtracted, because the logarithms decrease in proceeding backward 35″ from 30° 13′, to attain 30° 12′ 25″. The tangents and secants, in this example, are the same by both methods; the sines differ by one unit, in the last decimal place, and this will frequently happen, because the difference of the logarithms for 1′, sometimes differ one or two units from the mean values which are used in the three columns of differences. The error arising from this cause is generally diminished by using the *smallest* angle* S′, when the seconds of the proposed angle are *smaller* than 30″; or the *greatest* angle G′, when the number of seconds are *greater* than 30″. Thus, in the above example, where the angle S′ = 30° 12′, and the angle G′ = 30° 13′, it is best to use the angle S′ when the given angle is less than 30° 12′ 30″, but the angle G′ when it exceeds 30° 12′ 30″. Thus, if it be required to find the sine of 30° 12′ 51″, it is best to use the angle G′ = 30° 13′, and find the correction by entering the margin marked S′, with the difference 60″ — 51″ = 9″, opposite to which, in the column of differences, is 3, to be subtracted from log. sine of 30° 13′ = 9.70180, to get the log. sine of 30° 12′ 51″ = 9.70177. To save the trouble of subtracting the seconds from 60″, we may use the right-hand margin, marked G′, and the correction may then be found by the following rules:—

Rule 1. When the *smallest* angle S′ is used, *find the seconds in the column* S′, and take out the corresponding correction, which is to be applied to the logarithm corresponding to S′; by adding, if the log. of G′ be greater than the log. of S′; otherwise, by subtracting.

Rule 2. When the *greater* angle G′ is used, *find the seconds in the column* G′, and take out the corresponding correction, which is to be applied to the logarithm corresponding to G′; by adding, if the log. of S′ be greater than the log. of G′; otherwise, by subtracting; so that, in all cases, the required logarithm may fall between the two logarithms corresponding to the angles S′ and G′.

The correctness of these rules will evidently appear by comparing them with the preceding examples; and by the inverse process we may find the angle corresponding to a given logarithm, as in the next article.

We have given at the bottom of the page, in this table, a small table for finding the proportional parts for the odd seconds of time, corresponding to the column of Hours A. M. or P. M.; to facilitate the process of finding the log. sine, cosine, &c., corresponding to the nearest second of time in the column of hours, or, on the contrary, to find the nearest second of time corresponding to any given log. sine, cosine, &c. Thus, in the preceding examples, where the angle S′ = 30° 12′, and the

* If we neglect the seconds in any proposed angle whose sine, &c. is required, we get the angle denoted above by S′, and this angle increased by 1′, is represented by G′; so that the proposed angle falls between S′ and G′; S′ being a *smaller*, and G′ a *greater* angle than that whose log. sine, &c., is required; the letters S′ and G′, accented for minutes, being used because they are easily remembered as the initials of *smaller* and *greater*

Digitized by Google

angle G′ = 30° 13′; the times corresponding in the column of Hours P. M., are S′ = 4h 1m 36s; G′ = 4h 1m 44s; and if we wish to find the log. sine, cosine, &c., corresponding to any intermediate time, as, for example, 4h 1m 39s, which differs 3s from the angle S′, we must find the tabular logarithm corresponding to S′, and apply the correction for 3s, given by the table at the bottom of the page, as in the following examples:—

	A.	B.	C.
Logs. for S′ = 4h 1m 36s	Sine 9.70159	Tangent 9.76493	Secant 10.06334
Correction for + 3s	+ 8	+ 11	+ 3
Logs. for..... 4h 1m 39s	Sine 9.70167	Tangent 9.76504	Secant 10.06338

Nearly the same results are obtained by using the angle G′, in the manner we have before explained:—

Logs. for G′ = 4h 1m 44s	Sine 9.70180	Tangent 9.76522	Secant 10.06342
Correction for — 5s	— 13	— 18	— 5
Logs. for. ... 4h 1m 39s	Sine 9.70167	Tangent 9.76504	Secant 10.06337

These corrections must be applied by addition or subtraction, according to the directions given above, so as to make the required logarithm fall between those which correspond to the times S′ and G′.

The inverse process will give the time corresponding to any logarithm. Thus, if the log. sine 9.70167 be given, the difference between this and 9.70159, corresponding to S′ = 4h 1m 36s, is 8; seeking this in the column A, in the second line of the table at the bottom of the page, it is found to correspond to 3s; adding this to the time S′ = 4h 1m 36s, we get 4h 1m 39s for the required time. We may proceed in the same manner with the logarithms in the columns B, C; using the numbers corresponding, marked B, C, respectively, in the table at the bottom of the page.

To find the degrees, minutes, and seconds, corresponding to any given logarithm sine, cosine, &c. by Table XXVII.

Find the two nearest numbers to the given log. sine, cosine, &c., in the column marked *sine*, *cosine*, &c., respectively, one being greater, and the other less, and take their difference, D; take also the difference, *d*, between the given logarithm and the logarithm corresponding to the smallest number of degrees and minutes; then say, As the first found difference is to the second found difference, so is 60″ to a number of seconds to be annexed to the smallest number of degrees and minutes before found. The three columns of differences may also be used, by an inverse operation to that which we have explained in the preceding article.

EXAMPLE V.

Find the degrees, minutes, and seconds (less than 90°), corresponding to the log. sine 9.61400.

Next less log. S′ = 24° 16′	9.61382		Log. of smallest angle S′ = 24° 16′ is	9.61382
Greater..... G′ = 24 17	9.61411		Given log........................	9.61400
	D = 29			*d* = 18

Then say, As 29 : 18 : : 60″ : 38″, nearly; which, annexed to 24° 16′, give 24° 16′ 38″, answering to log. sine 9.61400. Subtracting 24° 16′ 38″ from 180°, there remain 155° 43′ 22″, the log. sine of which is also 9.61400. The quantity 38″ may also be found by inspection in the side column S′ of the page opposite *d* = 18, in the column of differences between the two columns, A, A. If we use the angle G′, we shall have *d′* equal to 11, the difference of the logarithms 9.61411 and 9.61400, and the corresponding number of seconds in column G′, is 37″, making 24° 16′ 37″.

To find the arithmetical complement of any logarithm.

The arithmetical complement of any logarithm is what it wants of 10.00000, and is used to avoid subtraction. For, when working any proportion by logarithms, you may add the arithmetical complement of the logarithm of the first term, instead of subtracting the logarithm itself, observing to neglect 10 in the index of the sum of the logarithms. The arithmetical complement of any logarithm is thus found:—Begin at the index, and *write down what each figure wants of* 9, *except the last significant figure, which take from* 10.* Thus, the arithmetical complement of 9.62595 is 0.37405; that of 1.86567 is 8.13433; and that of 10.33133 is 89.66867, or 9.66867.

* When the index of the given logarithm is greater than 10, as in some of the numbers of Table XXVII., the left-hand figure of it must be neglected; and when there are any ciphers to the right hand of the last significant figure, you may place the same number of ciphers to the right hand of the other figures of the arithmetical complement.

Digitized by Google

PLANE TRIGONOMETRY.

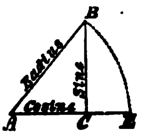
Plane Trigonometry is the science which shows how to find the measures of the sides and angles of plane triangles, some of them being already known. It is divided into two parts, right-angled and oblique-angled; in the former case, one of the angles is a right angle, or 90°; in the latter, they are all oblique.

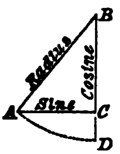
In every plane triangle there are six parts, viz. three sides and three angles; any three of which being given (except the three angles), the other three may be found by various methods, viz. by Gunter's scale, by the sliding rule, by the sector, by geometrical construction, or by arithmetical calculation. We shall explain each of these methods;* but the latter is by far the most accurate; it is performed by the help of a few theorems, and a trigonometrical canon, exhibiting the natural or the logarithmic sines, tangents, and secants, to every degree and minute of the quadrant.† The theorems alluded to are the following:—

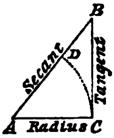
THEOREM I.

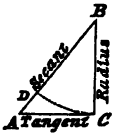
In any right-angled triangle, if the hypotenuse be made radius, one side will be the sine of the opposite angle, and the other its cosine; but if either of the legs be made radius, the other leg will be the tangent of the opposite angle, and the hypotenuse will be the secant of the same angle.

Fig. 1. Fig. 2. Fig. 3. Fig. 4.









1st. If, in the right-angled plane triangle ACB (fig. 1), we make the hypotenuse AB radius, and upon the centre, A, describe the arc BE, to meet AC produced in E, then it is evident that BC is the sine of the arc BE (or the sine of the angle BAC), and that AC is the cosine of the same angle; and if the arc AD be described about the centre B (fig. 2), AC will be the sine of the angle ABC, and BC its cosine.

2dly. If the leg AC (fig. 3) be made radius, and the arc CD be described about the centre A, CB will be the tangent of that arc, or the tangent of the angle CAB; and AB will be its secant.

3dly. If the leg BC (fig. 4) be made radius, and the arc CD be described about the centre B, CA will be the tangent of that arc, or the tangent of the angle B, and AB will be its secant.

Now, it has been already demonstrated (in *Art.* 55, Geometry) that the sine, tangent, secant, &c. of any arc in one circle is to the sine, tangent, secant, &c. of a similar arc in another circle as the radius of the former circle to the radius of the latter. And since in any right-angled triangle there are given either two sides, or the angles and one side, to find the rest, we may, if we wish to find a side, make any side radius; then say, As the tabular number of the same name as the given side is to the given side of the triangle, so is the tabular number of the same name as the required side, to the required side of the triangle. If we wish to find an angle, one of the given sides must be made radius; then say, As the side of the triangle made radius is to the tabular

* It will not be necessary to add any further description of the uses of the sector or sliding rule; for what we have already given will be sufficient for any one tolerably well versed in the use of Gunter's scale.

† See Tables XXIV. and XXVII.

Digitized by Google

radius, so is the other given side to the tabular sine, tangent, secant, &c. by it represented; which, being sought for in the table of sines, &c., will correspond to the degrees and minutes of the required angle.

THEOREM II.

In all plane triangles, the sides are in direct proportion to the sines of their opposite angles (by *Art.* 58, Geometry).

Hence, to find a side, we must say, As the sine of an angle is to its opposite side, so is the sine of either of the other angles to the side opposite thereto. But if we wish to find an angle, we must say, As any given side is to the sine of its opposite angle, so is either of the other sides to the sine of its opposite angle.

THEOREM III.

In every plane triangle, it will be, as the sum of any two sides is to their difference, so is the tangent of half the sum of the two opposite angles to the tangent of half their difference (by *Art.* 59, Geometry).

THEOREM IV.

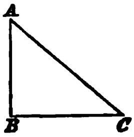
As the base of any plane triangle is to the sum of the two sides, so is the difference of the two sides to twice the distance of a perpendicular (let fall upon the base from the opposite angle) from the middle of the base (by *Art.* 60, Geometry).

THEOREM V.

In any plane triangle, as the rectangle contained by any two sides including a sought angle, is to the rectangle contained by the half sum of the three sides and the same half sum decreased by the other side, so is the square of radius to the square of the cosine of half the sought angle (by *Art.* 61, Geometry).

In addition to these theorems, it will not be amiss for the learner to recall to mind the following articles:—

1. In every triangle, the greatest side is opposite to the greatest angle, and the greatest angle opposite to the greatest side.
2. In every triangle equal sides subtend equal angles. (*Art.* 39, Geometry.)
3. The three angles of any plane triangle are equal to 180°. (*Art.* 35, Geometry.)
4. If one angle of a triangle be obtuse, the rest are acute; and if one angle be right, the other two together make a right angle, or 90°; therefore, if one of the acute angles of a right-angled triangle be known, the other is found by subtracting the known angle from 90°. If one angle of any triangle be known, the sum of the other two is found by subtracting the given angle from 180°; and if two of the angles be known, the third is found by subtracting their sums from 180°.
5. *The complement of an angle is what it wants of 90°, and the supplement of an angle is what it wants of 180°.*

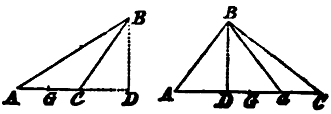


In the two following tables we have collected all the rules necessary for solving the various cases of Right-angled and Oblique-angled Trigonometry.

FORMULAS IN RIGHT-ANGLED TRIGONOMETRY.

Case.	Given.	Sought.	Solutions.
1	Hyp. AC. Angles.	Leg BC. Leg AB.	Rad. : hyp. AC : : sine A : leg BC. Rad. : hyp. AC : : sine C : leg AB.
2 & 3	Leg BC. Angles.	Leg AB. Hyp. AC.	Rad. : leg BC : : tang. C : leg AB. { Rad. : leg BC : : sec. C : hyp. AC. { Or, sine A : leg BC : : rad. : hyp. AC.
4 & 5	Hyp. AC. Leg AB.	Angles. Leg BC.	Hyp. AC : rad. : : leg AB : sine C, whose comp. is A. Rad. : hyp. AC : : sine A : leg BC.
6	Both legs. AB & BC.	Angles. Hyp. AC.	Leg BC : rad. : : leg AB : tang. C, whose comp. is A. { Sine C : leg AB : : rad. : hyp. AC. { Or, rad. : leg BC : : sec. C : hyp. AC.

Digitized by Google



FORMULAS IN OBLIQUE-ANGLED TRIGONOMETRY

Case.	Given.	Sought.	Solutions.
1	The angles and side AB.	Side BC. Side AC.	Sine C : side AB : : sine A : side BC. Sine C : side AB : : sine B : side AC.
2 & 3	Two sides, AB, BC, and angle C opposite to one of them.	Angle A. Angle B. Side AC.	Side AB : sine C : : side BC : sine A, which added to C, and the sum subtracted from 180°, gives B. Sine C : side AB : : sine B : side AC.
4 & 5	Two sides, AC, AB, and the included angle A.	Angles C and B.	Subtract half the given angle, A, from 90°; the remainder is half the sum of the other angles. Then say, As the sum of the sides, AC, AB, is to their difference, so is the tangent of the half sum of the other angles to the tangent of half their difference; which added to and subtracted from the half sum, will give the two angles B and C; the greatest angle being opposite to the greatest side.
		Side BC.	Sine B : side AC : : sine A : side BC.
6	All three sides.	All the angles.	Let fall a perpendicular, BD, opposite to the required angle; then, as AC : sum of AB, BC : : their difference : twice DG, the distance of the perpendicular from the middle of the base; hence, AD, CD, are known, and the triangle ABC is divided into two right-angled triangles, BCD, BAD; then, by Cases IV. and V. of Right-angled Trigonometry, we may find the angle A or C.
		Either angle, as A.	Either of the angles, as A, may also be found by the following rule. From half the sum of the three sides subtract the side BC opposite to the sought angle; take the logarithms of the half sum and remainder, to which add the arithmetical complements of the logarithms of the sides AB, AC (including the sought angle); half the sum of these four logarithms will be the logarithmic cosine of half the sought angle.

In calculating by logarithms by any of the preceding rules, you must remember, that *the logarithm of the first term of the analogy is to be subtracted from the sum of the logarithms of the second and third terms; the remainder will be the logarithm of the sought fourth term.*

When the first term is radius (whose logarithm is 10.00000), you need only reject a unit in the second left-hand figure of the index of the sum of the second and third terms. But when the radius occurs in the second or third term, you must suppose a unit to be added to the second left-hand figure of the index of the other term, and subtract therefrom the logarithm of the first term.

RIGHT-ANGLED TRIGONOMETRY.

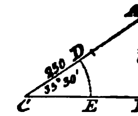
Solution of the six cases in Right-angled Trigonometry.

CASE I.

The angles and hypotenuse given, to find the legs.

Given the hypotenuse AC 250 leagues, and the angle C, opposite to the side AB, $=35° 30'$, to find the base CB, and perpendicular AB.

BY PROJECTION.



Draw the base CB of any length; with an extent equal to the chord of 60°, and on C as a centre, describe the arc DE; from E to D lay off 35° 30′ taken from the line of chords;* through C and D

* In all projections of this kind, the angles are measured from the line of chords; the radius used for describing arcs by which the angles are to be measured, being equal to the chord of 60°, the sides of

Digitized by Google

draw the line AC, which make equal to 250; from A let fall the perpendicular AB to cut CB in B, and it is done; for CB will be 203.5, and AB equal to 145.2.

BY LOGARITHMS.

By making the hypotenuse CA radius, it will be,

To find the base BC.

As radius....................	10.00000
Is to the hypotenuse AC 250..	2.39794
So is the sine angle A 54° 30′..	9.91069
To the base BC 203.5	2.30863

To find the perpendicular AB.

As radius....................	10.00000
Is to the hypotenuse AC 250..	2.39794
So is the sine angle C 35° 30′..	9.76395
To the perpendicular AB 145.2	2.16189

BY GUNTER'S SCALE.

In all proportions which are calculated by Gunter's scale, when the first and second terms are of the same kind, the extent from the first term to the second will reach from the third to the fourth.

Or, when the first and third terms are of the same kind,

The extent from the first term to the third will reach from the second to the fourth; that is, we must set one point of the compasses on the division expressing the first term, and extend the other point to the division expressing the third term; then without altering the opening of the compasses, we must set one point on the division representing the second term, and the other point will fall on the division showing the fourth term or answer.

In the present example the work is as follows:—

Extend from radius, or 90°, to 54° 30′ on the line of sines; that extent will reach from 250, the hypotenuse, to 203.5, the base on the line of numbers; and the extent from radius or 90°, to 35° 30′ on the line of sines, will reach from 250 to 145.2 on the line of numbers.

Observe the same method in all the following examples, except in those proportions where the word *secant* is mentioned, which cases must be wrought by considering the hypotenuse radius,* there being no line of secants on the common Gunter's scale, although it can easily be marked on the line of sines.

Note. The radius, according to the nature of the proportion, may be either of the following quantities:—

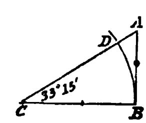
8 points on the line of rhumbs.	90° on the line of sines.
4 points on the line of tangent rhumbs.	45° on the line of tangents.

CASES II. AND III.

The angles and one leg given, to find the hypotenuse and other leg.

The angle ACB 33° 15′, the leg BC 163 miles, given, to find the hypotenuse and the other leg.

BY PROJECTION.



Draw the line BC, which make equal to 163 miles; on B erect the perpendicular BA; on C, as a centre, with the chord of 60°, sweep the arc BD, which make equal to 33° 15′; draw CD, and continue it to cut AB in A, and it is done; for AB being measured on the same scale that BC was, will be 106.9, and AC 194.9 miles.

BY LOGARITHMS.

By making the base BC radius, it will be,

To find the perpendicular AB.

As radius 45°	10.00000
Is to the base BC 163	2.21219
So is tangent angle C 33° 15′ ..	9.81666
To the perpendicular AB 106.9	2.02885

To find the hypotenuse AC.

As radius 90°...............	10.00000
Is to the base BC 163	2.21219
So is secant angle C 33° 15′ ...	10.07765
To the hypotenuse AC 194.9 ..	2.28984

the triangles are measured by scales of equal parts, as was before observed. Instead of using the line of chords, it is much more convenient to set off the angles by means of a protractor, or circular arc, on which the degrees are marked. Its construction is so simple that it needs no explanation.

* Or by using in the analogy, radius : cosine angle, instead of secant angle : radius; and radius : sine angle, instead of cosecant angle : radius.

Digitized by Google

BY GUNTER.

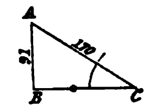
Extend from 45° to 33° 15′ on the line of tangents; that extent will reach from the base 163 to the perpendicular 106.9, on the line of numbers.

2dly. Extend from 56° 45′ to radius on the line of sines; that extent will reach from the base 163 to the hypotenuse 194.9, on the line of numbers.

CASES IV. AND V.

The hypotenuse and one leg given, to find the angles and other leg.

Given the leg AB 91, and the hypotenuse AC 170, being to find the angle ACB BAC, and the leg BC.



BY PROJECTION.

Draw BC at pleasure; on B erect the perpendicular BA, which make equal to 91; take 170 in your compasses, and, with one foot on A, describe an arc to cut BC in C; join A and C, and it is done; for the angle C is 32° 22′, the angle A 57° 38′, and BC 143.6.

BY LOGARITHMS.

By making the hypotenuse radius, we shall have,

To find the angle C.	
As the hypotenuse 170	2.23045
Is to radius	10.00000
So is the perpendicular 91	1.95904
To sine angle C 32° 22′	9.72859

To find the base BC.*	
As radius....................	10.00000
Is to the hypotenuse 170......	2.23045
So is the sine angle A 57° 38′..	9.92667
To the base BC 143.6........	2.15712

BY GUNTER.

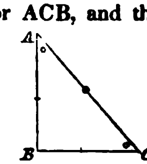
Extend from the hypotenuse 170 to the perpendicular 91, on the line of numbers; that extent will reach from radius to the angle C, or the complement of angle A = 32° 22′ on the line of sines.

2dly. Extend from radius to the angle A 57° 38′, on the line of sines; that extent will reach from the hypotenuse 170 to the base 143.6, on the line of numbers.

CASE VI.

The legs given, to find the angles and hypotenuse.

Given the legs AB 178, and BC 141, to find the angle BAC or ACB, and the hypotenuse AC.



BY PROJECTION.

Make BC equal to 141, and on B erect the perpendicular BA, which make equal to 178; join AC, and it is done; for the angle C is 51° 37′; consequently the angle A 38° 23′, and the hypotenuse 227.1.

BY LOGARITHMS.

By making the base radius, we shall have,

To find the angle C.	
As the base 141	2.14922
Is to radius	10.00000
So is the perpendicular 178 ...	2.25042
To tangent angle C 51° 37′....	10.10120

To find the hypotenuse AC.†	
As radius....................	10.00000
Is to the base 141............	2.14922
So is the secant angle C 51° 37′	10.20696
To the hypotenuse AC 227.1..	2.35618

BY GUNTER.

The extent from 141 to 178 on the line of numbers will reach from radius, or 45 degrees, to the angle C 51° 37′, on the line of tangents.

2dly. The extent from the angle C 51° 37′ to radius, or 90°, on the line of sines, will reach from the perpendicular 178, to the hypotenuse 227.1, on the line of numbers.

* When you take the log. sines, or tangents, to the nearest minute only, it is best to use this canon for finding BC, which is more correct than the one found by making the perpendicular radius, because the variation of the log. sine of an arc is less than the corresponding variation of the log. tangent.

† When finding AC, it is best to make the greatest side radius, for the reason mentioned in the last note so that in the present example it would be rather preferable to use the perpendicular 178 for the radius

Digitized by Google

QUESTIONS

To exercise the learner in Right-angled Plane Trigonometry.

Question 1. The hypotenuse 496 miles, and the angle opposite to the base 56° 15 given, to find the base and perpendicular.

Answer. Base 412.4, and the perpendicular 275.6 miles.

Quest. 2. The perpendicular 275 leagues, and the angle opposite to the base 56° 15 given, to find the hypotenuse and base.

Ans. The hypotenuse 495, and base 411.6 leagues.

Quest. 3. The base 33 yards, and the angle opposite to the perpendicular 53° 26 given, to find the hypotenuse and perpendicular.

Ans. Hypotenuse 55.39, and the perpendicular 44.49 yards.

Quest. 4. The hypotenuse 575, and perpendicular 50 miles, given, to find the base

Ans. Base 572.8 miles.

Quest. 5. The hypotenuse 59, and the base 33 miles, given, to find the perpendicular.

Ans. Perpendicular 48.9 miles.

Quest. 6. The base 33, and perpendicular 52 leagues, given, to find the hypotenuse

Ans. Hypotenuse 61.59 leagues.

OBLIQUE TRIGONOMETRY.

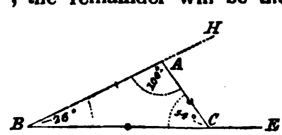
CASE I.

Two angles and one side given, to find either of the legs.

Given the angle BAC $=100°$, the angle ACB $=54°$, and the leg AB $=220$, to find the sides.

BY PROJECTION.

Subtract the sum of the angles A and C from 180°; the remainder will be the angle B $=26°$. Draw the indefinite line BE, also the line BH, making the angle EBH $=26°$; on BH set off BA 220. On A make the angle BAC 100°; then AC will intersect the line BE in the point C, which completes the triangle, and BC will measure (on the same scale from which BA was laid down) 268 nearly, and AC 119.



BY LOGARITHMS, BY THEOREM II.

To find BC.	
As the sine of the angle C 54° ..	9.90796
Is to the side AB 220	2.34242
So is the sine of the angle A 100°	9.99335
	12.33577
	9.90796
To the side BC 267.8	2.42781

To find AC.	
As sine angle C 54°	9.90796
Is to the side AB 220	2.34242
So is the sine angle B 26°	9.64184
	11.98426
	9.90796
To the side AC 119.2	2.07630

BY GUNTER.

The extent from the angle C $=54°$ to the angle A, or its supplement 80°, on the sines, will reach from AB $=220$ to BC $=268$, on the line of numbers.

2dly. The extent from the angle C $=54°$ to the angle B $=26°$, on the sines, will reach from AB $=220$ to AC $=119$, on the line of numbers.

Digitized by Google

CASES II. AND III.

Two sides, and an angle opposite to one of them, being given, to find the other angles, and the third side.

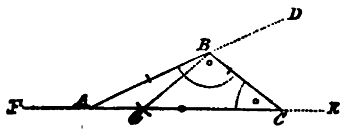
Note. It may be proper to observe, that if the given angle be obtuse, the angle sought will be acute; but when the given angle is acute, and opposite to a shorter given side, then it is doubtful whether the required angle be acute or obtuse; it ought therefore to be given by the conditions of the problem.

EXAMPLE.

Let there be given the side BC 137, the side AB 213, and the angle A 23½°, to find the other side AC, and the angles ABC, BCA.

BY PROJECTION.

Draw the indefinite line FE; make the angle DAE = 23½°; on AD set off AB = 213 then on B, with 137 in your compasses, taken from the same scale, describe an arc cutting FE in the points C and G; join BC, BG, and it is done; for the triangle may be either ACB or AGB, according as the angle C or G is acute or obtuse; if that angle be acute, the triangle will be ABC; the side AC will measure 303, the angle ACB will measure 38½°, and the angle ABC will measure 118° nearly;



but if the angle at the base be obtuse, the triangle will be AGB; the side AG will measure 88, the angle AGB will measure 141⅔°, and the angle ABG 15°, nearly.

If the side BC had been given greater than AB, there could have been only one answer to this problem; for in that case, the point G would have fallen on the continuation of the line CA towards F, in which case the angle A of the triangle would become equal to FAB, instead of being equal to its supplement, as is required by the conditions of the problem.

BY LOGARITHMS, BY THEOREM II.

To find the angle C or G.

As the side BC 137				2.13672
Is to the sine of angle A 23½°				9.60070
So is the side AB 213				2.32838
				11.92908
				2.13672
To sine angle C	38 19	or G	141 41	9.79236
Angle A, add ..	23 30		23 30	
Subtract......	61 49	or	165 11	
From	180 0		180 0	
Angle ABC....	118 11	ABG	14 49	

To find AC.

As sine angle C 38° 19′	9.79240
Is to AB 213	2.32838
So is sine angle ABC 118° 11′	9.94519
	12.27357
	9.79240
To the side AC 302.8	2.48117

To find AG.

As sine angle G 141° 41′	9.79240
Is to AB 213	2.32838
So is sine angle ABG 14° 49′	9.40778
	11.73616
	9.79240
To the side AG 87.9	1.94376

BY GUNTER.

1st. The extent from BC = 137 to AB = 213, on the line of numbers, will reach from A = 23½° to 38° 19′, on the line of sines, which is equal to the angle C; its supplement, 141° 41′, being equal to the angle G.

2dly. The extent from the angle C = 38° 19′ to 61° 49′ (the supplement of the angle ABC, 118° 11′) on the sines, will reach from AB = 213 to 303, nearly, on the line of numbers; therefore the side AC = 303.

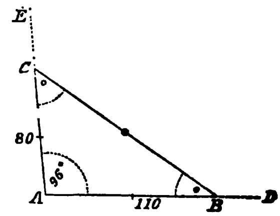
Or, the extent from 38° 19′ (the supplement of the angle G) to the angle ABG = 14° 49′, on the sines, will reach from AB = 213 to 88, on the line of numbers; hence AG = 88.

Digitized by Google

CASES IV. AND V.

Two sides and their contained angle being given, to find either of the other angles and the third side.

Given the side AB 110 miles, AC 80 miles, and angle BAC 96° 0′, to find the angles BCA and CBA and the side BC



BY PROJECTION.

Draw the indefinite right line AD, on which set off AB = 110; make the angle EAB = 96°; and on AE set off AC = 80; join BC, and it is done; for BC will measure on the former scale 143, and the angles B and C will measure 33° 55′ and 50° 5′, respectively, on the line of chords.

BY LOGARITHMS.

To find the angles B and C, by Theorem III.

As sum of sides AC and AB 190		2.27875
Is to their difference 30		1.47712
So is tang. ½ sum opp. angles or complement of ½ angle A	42°	9.95444
		11.43156
		2.27875
To tangent of half difference	8° 5′ =	9.15281
Sum is angle C	50 5	
Difference is angle B	33 55	

To find the side BC, by Theorem II.

As sine angle B 33° 55′	9.74662
Is to AC 80	1.90309
So is sine angle A 96° 0′ or its supplement 84 0	9.99761
	1.90070
	9.74662
To side BC 142.6	2.15408

BY GUNTER.

1st. The extent from the sum of the sides, 190, to their difference, 30, on the line of numbers, will reach from the half sum of the angles B and C, 42°, to their half difference, 8° 5′, on the line of tangents. The sum of this half sum and half difference gives the angle C 50° 5′, and their difference the angle B 33° 55′; the greatest angle being opposite to the greatest side.

2dly. The extent from the angle B 33° 55′, to the angle A 96° (or its supplement, 84°) on the line of sines, will reach from the side AC 80, to the side BC 142.6, on the line of numbers.

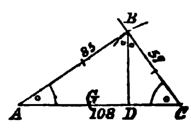
CASE VI

The three sides of a plane triangle given, to find the angles.

The sides AB 85, BC 57, AC 108, given, to find the angles ABC, BAC, BCA.

BY PROJECTION.

Draw the line AC, and make it equal to 108; take 85 in your compasses, and, with one foot on the point A, describe an arc; then take the distance 57 in your compasses, and, with one foot on C, describe another arc intersecting the former arc in the point B; join AB, CB, and it is done; for the angle A being measured will be found = 31½°, B = 97°, and the angle C = 51½°, nearly.



BY LOGARITHMS, BY THEOREM IV.

Suppose BD to be drawn perpendicular to AC, and that AG = GC.

Side AB =	85
Side BC =	57
Sum of the sides	142
Difference of the sides	28
Half base AC	54
DG	18.4
Sum is greatest segment AD	72.4
Difference is least segment DC	35.6

As the base AC 108 ....Log.	2.03342
Is to the sum of the sides AB and BC 142 ....Log.	2.15229
So is the difference of the sides AB and BC 28 ....Log.	1.44716
	3.59945
	2.03342
To twice DG 36.8 ....Log.	1.56603
Its half is DG 18.4	

Digitized by Google

Having divided the triangle into two right-angled triangles, the hypotenuses and bases of which are given, we may find the angles by Theorem I.

To find the angle BAD.

As the hypotenuse AB 85	Log.	1.92942
Is to radius 90°	Log.	10.00000
So is the greatest seg. AD 72.4 ...	Log.	1.85974
To cosine BAD = 31° 36′........	Log.	9.93032

To find the angle BCD.

As the hypotenuse BC 57........	Log.	1.75587
Is to radius 90°................	Log.	10.00000
So is the least segment DC 35.6...	Log.	1.55145
To cosine of BCD = 51° 21′.....	Log.	9.79558

BAD =	31	36
Sum	82	57
Subtract from	180	00
Remains angle ABC	97	03

BY GUNTER'S SCALE.

1st. The extent from the base AC = 108, to the sum of the sides 142, on the line of numbers, will reach from the difference of the sides 28, to twice DG 36.8, on the same line of numbers.

2dly. The extent from the hypotenuse AB = 85, to the greater segment AD 72.4, on the line of numbers, will reach, on the sines, from the radius 90°, to 58° 24′, which is the complement of the angle BAD.

3dly. The extent from the hypotenuse BC 57, to the least segment, DC 35.6, on the line of numbers, will reach on the sines from the radius 90°, to 38° 39′, which is the complement of the angle BCA.

This case may be solved without dividing the triangle into two right-angled triangles, by Theorem V.

To find the angle A.

BC =	57		
AB =	85	Arith. Comp. Log.	8.07058
AC =	108	Arith. Comp. Log.	7.96658
Sum	250		
Half sum	125	.... Log.	2.09691
Half sum less BC	68	.... Log.	1.83251
		Sum..........	)19.96658
Half sum....	15° 48′	Cosine Log.	9.98329
	2		
Doubled is ..	31 36	= angle A.	

Having the angle A, we may find the angle C by Theorem II.

As BC 57........................	Log.	1.75587
Is to sine angle A 31° 36′..........	Log.	9.71932
So is AB 85	Log.	1.92942
		11.64874
		1.75587
To the sine of angle C 51° 23′	Log.	9.89287

ASTRONOMY AND GEOGRAPHY.

Astronomy is the science which treats of the motions and distances of the heavenly bodies, and of the appearances thence arising.

Geography is the science which treats of the situations and distances of the various parts of the surface of the earth.

The common opinion of astronomers of the present day is, that the universe is composed of an infinite number of systems or worlds; that in every system there are certain bodies moving in free space, and revolving, at different distances, round a sun, placed in or near the centre of the system; and that these suns, and other bodies, are the stars which are seen in the heavens.

The Solar System, so called, is that in which our earth is placed, and in which the sun is supposed to be fixed near the centre, with several bodies, similar to our earth, revolving round at different distances. This hypothesis, which is fully confirmed by observation, is called the Copernican System, from Nicholas Copernicus, a Polish philosopher, who revived it about the year 1500, after it had been buried in oblivion many ages.

Stars are distinguished into two kinds, *fixed* and *wandering*. The former are supposed to be suns in the centres of their systems, shining with their own light, and preserving nearly the same situation with respect to each other. They are usually distinguished by their brightness, the largest being called of the first magnitude, and the smallest visible to the naked eye being of the sixth or seventh magnitude. A *Constellation* is a number of stars which appear near to each other on the concave surface of the heavens, and astronomers, for the sake of remembering them with greater ease, suppose them to be circumscribed by the outlines of some animal or other figure. Wandering stars are those bodies within our system, or celestial sphere, which revolve round the sun; they appear luminous by reflecting the light of the sun, and are of three kinds, namely, *primary planets*, *secondary planets*, and *comets*.

The *Primary Planets* are bodies which revolve round the sun as the centre of their courses, the motions being regularly performed in tracks or paths, called *orbits*, that are nearly circular and concentrical with each other. A *Secondary Planet*, *Satellite*, or *Moon*, is a body which, while it is carried round the sun, revolves also round a primary planet. *Comets* are bodies which move round the sun in very excentrical orbits, with vast atmospheres about them, and tails derived from the same.

There are seventeen primary planets,* which, reckoned in order from the sun, are as follows:—Mercury, Venus, the Earth, Mars, Vesta, Juno, Pallas, Ceres, Astrea, Hebe, Iris, Flora, Metis, Jupiter, Saturn, Uranus, and Neptune.

Mercury and Venus are called *inferior planets*, because their orbits are within the earth's; the others are called *superior planets*, as their orbits include that of the earth.

The Sun, the first and greatest object of astronomical knowledge, is placed near the centre of the orbits of all the planets, and turns round its axis in 25¼ days. Its diameter is 883,000 English miles, and its mean distance from the earth 95 millions of miles.

Mercury is the least of all the planets known before the discovery of Vesta, Juno, Pallas, and Ceres, and is the nearest to the sun, his mean distance from that luminary being 37 millions of miles. His periodic revolution in his orbit round the sun is performed in 87 days 23 hours, and his diameter is about 3200 miles.

Venus is the brightest of all the planets. Her diameter is 7687 miles; her mean distance from the sun, 69 millions of miles; and her periodic revolution is performed in 224 days 17 hours. When this planet is in that part of her orbit which is west of the sun, she rises before him in the morning, and is called the *morning star*; when she is in the eastern part of her orbit, she shines in the evening, after he sets, and is called the *evening star*.

The next planet is the Earth, the diameter of which is 7914 miles, the distance from the sun 95 millions of miles, and the time of revolution round the sun, one year. The earth turns round its axis from west to east in 23 hours 56 minutes, which occasions the apparent diurnal motion of the sun and all the heavenly bodies round it

* The number is eighty-eight. Oct., 1864.

Digitized by Google

from east to west in the same time, and is, of course, the cause of their rising and setting, of day and night. The axis of the earth is inclined about 23° 28′ to the plane of its orbit,* and keeps nearly in a direction parallel to itself, throughout its annual course, which causes the return of spring and summer, autumn and winter. Thus the diurnal motion gives us the grateful vicissitude of night and day, and the annual motion the regular succession of the seasons. The earth is attended by a satellite called the MOON, whose diameter is 2161 miles. Her distance from the centre of the earth is 240,000 miles. She goes round her orbit in 27 days 8 hours; but, reckoning from change to change, in 29½ days. Her orbit is inclined to the ecliptic in an angle of 5° 9′, cutting it in two points diametrically opposite to each other, called her *nodes.* As the moon shines only by the reflected light of the sun, she must appear different when in different situations with respect to that luminary. When she is in conjunction with the sun, her dark side is turned towards the earth, which renders her invisible; this is called *new moon:* when she is in opposition, her light side is wholly visible from the earth; this is called *full moon.*

If at the time of new moon she is near to either of her nodes, she may intercept a part of the sun's light, and thus cause an *eclipse of the sun;* and if she is near either of her nodes at the time of full moon, she may pass into the shadow of the earth, and cause an *eclipse of the moon.* In a similar manner, when the moon passes between an observer on the earth and a star, it is called an *occultation* of the star. The instant when the moon's limb first covers the star is called the *immersion,* and the moment of its reappearance is called the *emersion.* When Mercury or Venus passes between the sun and an observer, and appears to pass over the sun's disk, it is called a *transit* of Mercury or Venus. Eclipses, occultations, and transits, are of great importance in ascertaining the longitudes of places on the earth. Eclipses of the moon furnish a convincing proof of the rotundity of the earth, since the shadow of the earth, seen upon the moon when eclipsed, is always circular. This is further confirmed by the appearance of objects at sea; for when a ship is making towards the land, the mariners first descry the tops of steeples, trees, &c., pointing above the water; the lower parts being hid, by reason of the curvature of the earth.

The earth is not a perfect globe or sphere, but is a little flattened at the poles, being nearly of the figure of an oblate spheroid, the equatorial diameter being about 26 miles longer than the polar; but since this difference bears but a small comparison to the whole diameter, we may, for all the practical purposes of navigation, consider the earth as a perfect sphere, as will be done in the rest of this work. The natural divisions of the earth will be given hereafter.

MARS is the next planet to the earth. His diameter is 4189 miles. His distance from the sun is 144 millions of miles, and his periodic revolution is performed in about 687 days. He revolves round his axis in 24 hours 40 minutes, appearing of a dusky-reddish hue, and is supposed to be encompassed with a very great atmosphere.

Between Mars and Jupiter are situated eleven planets,§ or asteroids, viz. Vesta, Juno, Pallas, Ceres, Astrea,† Hebe, Iris, Flora, Metis, Hygeia and Parthenope.

VESTA was discovered by Dr. Olbers, of Bremen, on the 29th of March, 1807. Its mean distance from the sun is about 224 millions of miles. Its periodic revolution is performed in 1325 days.

JUNO was discovered by Mr. Harding, of Lilienthal (near Bremen), on the first of September, 1804. It appears like a star of the eighth magnitude. Its distance from the sun is about 254 millions of miles. Its periodic revolution is performed in 1593 days. The inclination of its orbit to the ecliptic is 13° 4′, and the excentricity of the orbit † 0.25.

PALLAS was also discovered by Dr. Olbers, March 28, 1802. Its diameter, according to Dr. Herschel, is only 110 miles. It appears like a star of the eighth magnitude. Its mean distance from the sun is about 263 millions of miles. Its periodic revolution is performed in 1686 days. The inclination of its orbit to the ecliptic is 34° 35′, and the excentricity of the orbit 0.242.

CERES was discovered by Mr. Piazzi, of Palermo, on the first of January, 1801. Its diameter, according to Dr. Herschel, is only 160 miles. It appears like a star of the seventh or eighth magnitude. Its distance from the sun is about 263 millions of miles, and its periodic revolution is performed in 1685 days, being at nearly the same distance from the sun as Pallas. The inclination of the orbit of Ceres to the ecliptic is 10° 37′,

* The inclination decreases at present about 50″ in 100 years, by reason of the attraction of the planets on the earth. It is also affected by the nutation given in Table XLIII., which sometimes amounts to 9″

† Astrea was discovered by Mr. Hencke, of Dresden, Dec. 8, 1845.

Hebe	do.	do.	do.	do.	July 4, 1847.
Iris	do.	do.	Mr. Hind,	London,	Aug. 13, 1847.
Flora	do.	do.	do.	do.	Oct. 18, 1847.
Metis	do.	do.	Mr. Graham,	Sligo,	May, 1848.
Hygeia	do.	do.	M. Gasparis,	Naples,	April, 1849.
Parthenope	do.	do.	do.	do.	May 11, 1850.

‡ In estimating the excentricities of the planets, their mean distance from the sun is put equal to unity.

§ Now (October, 1864) eighty.

Digitized by Google

and the excentricity 0.077. The situations of the nodes of the two planets, Ceres and Pallas, and the inclinations of their orbits, are very different from each other, so that when those planets are in the same plane, they are at a great distance from each other notwithstanding their mean distances from the sun are nearly equal. It has been supposed by some, that these small bodies are fragments of a former planet.

JUPITER is situated still higher in the system, and is the largest of all the planets, being easily distinguished from them by his peculiar magnitude and light. His diameter is 89,170 miles; his distance from the sun 494 millions of miles; and the time of his periodic revolution is 4332½ days. Though Jupiter is the largest of all the planets, yet his diurnal revolution is the swiftest, being only 9 hours and 56 minutes.

Jupiter is attended by four satellites, invisible to the naked eye; but through a telescope they make a beautiful appearance. In speaking of them, we distinguish them according to their places, into the first, second, and so on; by the first we mean that which is nearest to the planet. The appearance of these satellites is marked in the XIXth page of the Nautical Almanac for some particular hour of the night; the times when they are eclipsed, by passing into the shadow of Jupiter, are also given in the Nautical Almanac; these eclipses are of some use in determining the longitudes of places on the earth.

Before the discovery of the planet Uranus, SATURN was reckoned the most remote planet of our system. He shines with but a pale and feeble light. His diameter is 79,042 miles; his distance from the sun 907 millions of miles; and his periodic revolution in his orbit is performed in about 29 years 167 days. This planet is surrounded with a broad, flat ring, has a diurnal revolution round its axis, and is attended by seven satellites.

By some observations made by Dr. Herschel, it appeared that the largest diameter of Saturn corresponds to the latitude of 45°; but from later observations he has been induced to believe, that this irregularity is owing to an optical deception, arising from the refraction of the light in passing through the atmosphere of the ring.

URANUS. Herschel, or Georgium Sidus, was discovered in the year 1781. by Dr. Herschel, though it had been seen several times, but had been considered as a fixed star. Its diameter is 35,109 miles; its distance from the sun is 1823 millions of miles; and its periodic revolution in its orbit is performed in 83½ years. Dr. Herschel has also discovered six satellites attending this planet.

NEPTUNE, the most remote planet of our system, was seen by Dr. Galle, of Berlin, Oct. 23, 1846. Its mean distance from the sun is 2867 millions of miles—its diameter is 31,750 miles, and its period of revolution is 165⅞ years. Mr. Lascelles has discovered one satellite.

The astronomy of comets is yet in its infancy. The return of one of them in the year 1758 was foretold by Dr. Halley, and it happened as he predicted; and it appeared again in 1835. He also foretold the return of another in the year 1790, but it never appeared. This was owing to the inaccuracy of the observations of the comet at its former appearance; for Mr. Mechain, having collected all the observations, and calculated the orbit again, found it to differ essentially from that determined by Dr. Halley. Olber's comet, which appeared in 1815, has a revolution of 72 years; and Encke's comet, which has been observed in several successive approaches to the perihelion, completes its revolution in the short period of 1204 days. Biela's comet has also been observed several times, with a periodical revolution of about 6¾ years.*

Comets move round the sun in all directions; but the planets and satellites, except one of the satellites of Uranus, move from west to east when seen from the sun; but if viewed from any other of the planets, as the earth, they would appear to revolve round it as a centre, but the sun would be the only one that moves uniformly the same way, for the other planets would sometimes appear to move from west to east, and then to stand still; then they would seem to move from east to west; and, after standing some time, they would again move from west to east; and so on, continually. The motion of a planet from west to east is called the *direct* motion, or *according to the order of the signs*. The contrary motion, from east to west, is called *retrograde*. When the planet appears to stand still, it is said to be *stationary*.

To illustrate what has already been said relative to the motions and distances of the planets and satellites, we have given the adjoining Plates III. and IV., which require no explanation.

In noting the situations of the stars and planets, astronomers have been under the necessity of imagining various lines and circles on the sphere; and geographers have done the same for fixing the situation of places on the earth. The most remarkable of these are the following:—

A *great circle* is that whose plane passes through the centre of the sphere; and a *small circle* is that whose plane does not pass through that centre.

A diameter of a sphere, perpendicular to any great circle, is called the *axis* of that circle; and the extremities of a diameter are called its *poles*. Hence the pole of a great circle is 90° from every point of it upon the surface of the sphere; but as the

* Twenty comets, with periods varying from 3 3 years to 3065 years, are now known. October, 1864.

Digitized by Google

axis is perpendicular to the circle when it is perpendicular to any two radii, a point on the surface of a sphere 90° distant from any two points of a great circle, will be the pole.

All angular distances on the surface of a sphere, to an eye at the centre, are measured by arcs of *great* circles. Hence all triangles formed upon the surface of a sphere, for the solution of spherical problems, must be formed by the arcs of great circles.

Secondaries to a great circle are great circles which pass through its poles, and consequently must be perpendicular to their great circles.

The *axis* of the earth is that diameter about which it performs its diurnal motion and the extremities of this diameter are called the poles.

The *terrestrial equator* is a great circle of the earth perpendicular to its axis. Hence the axis and poles of the earth are the axis and poles of its equator. That half of the earth which lies on the side of the equator in which Europe and the United States of America are situated, is called the *northern hemisphere*, and the other the *southern*; and the poles are respectively called the *north* and *south* poles.

The *latitude* of a place upon the earth's surface is its angular distance from the equator, measured upon a secondary to it. These secondaries to the equator are called *meridians*.

The *longitude* of a place on the earth's surface is an arc of the equator intercepted between the meridian passing through the place, and another, called the *first meridian*, passing through that place from which you begin to measure; or it is the angle formed at the pole by these two meridians. The Americans and English generally place the first meridian at Greenwich; the French place it at Paris, the Spaniards at Cadiz; some geographers place it at Teneriffe, and others at other places. Throughout this work, Greenwich will be reckoned as the first meridian. The longitude is counted from the first meridian, both eastward and westward, till it meets at the same meridian on the opposite point; therefore the longitude (and also the difference of longitude between any two places) can never exceed 180°.

If the plane of the *terrestrial equator* be produced to the sphere of the fixed stars, it marks out a circle called the *celestial equator*; and if the axis of the earth be produced in like manner, the points of the heavens, to which it is produced, are called *poles*, being the *poles* of the celestial equator. The star nearest to each pole is called the *pole* star.

Secondaries to the celestial equator are called *circles of declination*; of these 24, which divide the equator into equal parts, each containing 15°, are called *hour* circles.

Small circles parallel to the celestial equator are called *parallels* of declination.

The *sensible* horizon is that circle in the heavens whose plane touches the earth at the spectator. The *rational* horizon is a great circle in the heavens, passing through the earth's centre, parallel to the sensible horizon.

If the radius drawn from the centre of the earth to the place where the spectator stands be produced both ways to the heavens, the point vertical to him is called the *zenith*, and the point opposite, the *nadir*. Hence the *zenith* and *nadir* are the poles of the rational horizon.

Secondaries to the horizon are called *vertical* circles, because they are perpendicular to the horizon. On these circles, therefore, the altitude of a heavenly body is measured.

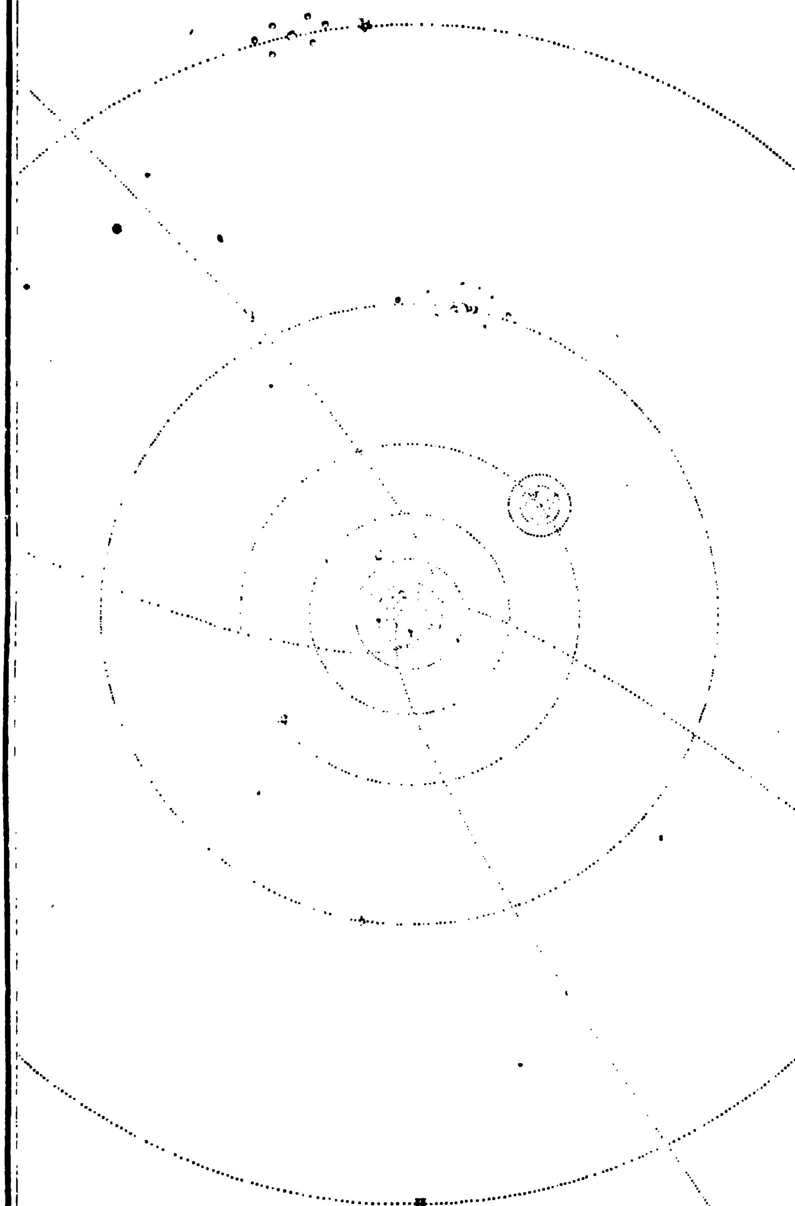
The secondary common to the celestial equator, and the horizon of any place, is the *celestial meridian* of that place. This meridian corresponds with the *terrestrial meridian* of the same place, which passes through the poles of the earth, the zenith and nadir crossing the equator at right angles, and cutting the horizon in the north and south points; that point being called *north* which passes through the north pole, and the opposite direction is called *south*. The vertical circle which cuts the meridian of any place at right angles is called the *prime* vertical; the points where it cuts the horizon are called the *east* and *west* points, and to an observer, with his face directed towards the south, the *east* point will be to his left hand, and the *west* to his right hand. Hence the east and west points are 90° distant from the north and south. These four are called the *cardinal* points. The meridian of any place divides the heavens into two hemispheres, lying to the east and west; that lying to the east is called the *eastern* hemisphere, and the other the *western* hemisphere. When the sun is at its greatest altitude on the meridian of any place, it is noon, or mid-day.

The *azimuth* of a heavenly body is its distance on the horizon, when referred to it by a secondary, from the north or south points. The *amplitude* is its distance from the east or west points, at the time of rising or setting.

The *ecliptic* is that great circle in the heavens which the sun appears to describe in the course of a year. ~~The ecliptic and equator, being great~~ circles, must bisect each other, and their angle of inclination is called the *obliquity of the ecliptic*; and the points where they intersect are called the *equinoctial points*. The times when the sun comes

Digitized by Google

THE SOLAR SYSTEM.



1 ☿ Mercury
2 ♀ Venus
3 ⊕ Earth & Moon
4 ♂ Mars
5 Juno Pallas Ceres & Vesta
6 ♃ Jupiter & his 4 Moons
7 ♄ Saturn & his 7 Moons
8 ♅ Uranus & his 6 Moons

Each of the two elliptical curves represents the orbit of a Comet

Digitized by Google

Digitized by Google

to these points are called the *equinoxes*. The ecliptic is divided into 12 equal parts, called *signs*:—viz. Aries ♈, Taurus ♉, Gemini ♊, Cancer ♋, Leo ♌, Virgo ♍, Libra ♎, Scorpio ♏, Sagittarius ♐, Capricornus ♑, Aquarius ♒, Pisces ♓. The order of these is according to the apparent motion of the sun. The first point of Aries coincides with one of the equinoctial points, and the first point of Libra with the other The first six signs are called *northern*, lying on the north side of the equator; and the last six are called *southern* lying on the south side.

The *zodiac* is a space extending eight degrees on each side the ecliptic, within which the motion of all the planets is contained, except the newly-discovered planets.

The *right ascension* of a body is an arc of the equator intercepted between the first point of Aries, and a circle of declination passing through the body, measured according to the order of the signs.

Right ascension of the meridian, or mid-heaven, is the distance of the meridian from the first point of Aries, and is found by adding the apparent time past noon to the sun's right ascension.

The *ascensional difference* of any object is the difference between the right ascension of the object and that point of the equator which rises or sets with it.

The *declination* of a star or any celestial object is its angular distance from the equator, measured upon a secondary to it passing through the object.

The *longitude* of a star or any celestial object is an arc of the ecliptic intercepted between the first point of Aries, and a secondary to the ecliptic passing through the body, measured according to the order of the signs. If the observer be on the earth, the longitude is called the *geocentric* longitude; but if seen from the sun, it is called the *heliocentric* longitude; the body in each case being referred perpendicularly to the ecliptic in a plane passing through the eye.

Nonagesimal degree of the ecliptic is its highest point at any given time, and is 90° from the points where the ecliptic intersects the horizon.

The *latitude* of a star or any celestial object is its angular distance from the ecliptic, measured upon a secondary to it drawn through the body. If the body be observed from the earth, its angular distance from the ecliptic is called the *geocentric* latitude; but if observed from the sun, it is called the *heliocentric* latitude. The secondary circle drawn perpendicular to the ecliptic is called a *circle of latitude*.

The *tropics* are two parallels of declination touching the ecliptic. One, touching it at the beginning of Cancer, is called the *tropic of Cancer;* and the other touching it at the beginning of Capricorn, is called the *tropic of Capricorn*. The two points where the tropics touch the ecliptic are called the *solstitial* points.

Colures are two secondaries to the celestial equator, one passing through the equinoctial points, called the *equinoctial* colure; and the other passing through the solstitial points, called the *solstitial* colure. The times when the sun comes to the solstitial points are called the *solstices*.

Aberration of a star, or any heavenly body, is a small apparent motion, occasioned by the progressive velocity of light. This is calculated by means of Tables XXXIX., XLI., or XLII.

Nutation is a small apparent motion of the heavenly bodies, occasioned by a real motion of the earth's axis, arising from the attractions of the sun and moon on the spheroidal form of the earth. The effect of this on the right ascension and declination is given in Table XLIII., and on the longitude in Table XL.; the correction in this last table being generally called the equation of the equinoxes in longitude.

Precession of the equinoctial points is a small motion of about 50¼″ per year, occasioned by the same cause as the nutation. By this motion the equinoctial points are carried backward from east to west; consequently, the heavenly bodies appear to move forward the same quantity from west to east. The annual variations of the places of the stars from precession, and the secular equations arising from the change of the earth's orbit by the attraction of the planets, are given in Tables VIII. and XXXVII.

The *arctic* and *antarctic* circles are two parallels of declination, the former about the north, and the latter about the south pole, the distance of which, from the two poles, is equal to the distance of the tropics from the equator, which is about 23° 28′. These are also called polar circles. The two tropics and two polar circles, when referred to the earth, divide it into five parts, called *zones;* the two parts within the polar circles are called the *frigid* zones; the two parts between the polar circles and tropics are called the *temperate* zones; and the part between the tropics is called the *torrid* zone.

Besides the imaginary divisions of the earth, there are various natural divisions of its surface, such as continents, oceans, islands, seas, rivers, &c.

A *continent* is a large tract of land, wherein are several empires, kingdoms, and countries conjoined; as Europe, Asia, Africa, and America.

Digitized by Google

An *island* is a part of the earth that is environed or encompassed round by the sea as Long Island, Block Island, &c.

A *peninsula* is a portion of land almost surrounded with water, save one narrow neck which joins it to the continent; as the Morea.

An *isthmus* is a narrow neck of land joining a peninsula to the adjacent land, by which the people may pass from one to the other: as the isthmus of Darien.

A *promontory* is a high part of land stretching itself into the sea, the extremity of which is called a *cape* or *headland*.

A *mountain* is a rising part of dry land, overtopping the adjacent country.

An *ocean* is a vast collection of water, separating continents from one another, and washing their borders or shores; as the Atlantic and Pacific Oceans.

A *sea* is part of the ocean, to which we must sail through some strait; as the Mediterranean and Baltic Seas. This term is sometimes used for the whole body of salt water on the globe.

A *strait* is a narrow part of the ocean lying between two shores, and opening a way into some sea; as the Straits of Gibraltar, that lead into the Mediterranean Sea.

A *creek* is a small narrow part of the sea or river, that goes up but a little way into the land.

A *bay* is a great inlet of the land; as the Bay of Biscay, and the Bay of Mexico; otherwise a bay is a station or road for ships to anchor in.

A *river* is a considerable stream of water issuing out of one or various springs, and continually gliding along in one or more channels, till it discharges itself into the ocean: the smaller streams are called *rivulets*.

A *lake* is a large collection of waters in an inland place; as the Lakes Superior and Huron in America.

A *gulf* is a part of the ocean or sea, nearly surrounded by the land, except where it communicates with the sea; as the Gulf of Venice.

Thus we have given the most useful definitions of Astronomy and Geography, and to assist the learner there is also given Plate V., in which those terms are explained at one view. We may further observe, that, as the latitude of any place upon the earth is counted from the equator upon an arc of the meridian, the difference of latitude between two places, both north or both south, is found by *subtracting the less latitude from the greater; but if one latitude be north, and the other south, the difference is found by adding both latitudes together.*

1. Consequently, if a ship in north latitude sails northerly, or in south latitude southerly, she increases her latitude; but in north latitude sailing southerly, or in south latitude sailing northerly, she decreases her latitude, because she sails nearer to the equator, from whence the latitude is reckoned.

2. Wherefore, *in north latitude sailing northerly, or in south latitude sailing southerly, the difference of latitude, added to the latitude left, gives the latitude in.*

3. *In north latitude sailing southerly, or in south latitude sailing northerly, the difference of latitude, subtracted from the latitude left, gives the latitude in.*

4. *When the latitude decreases, and the difference of latitude is greater than the latitude sailed from, subtract the latitude left from the difference of latitude, and the remainder will be the latitude in, but of a different name, for it is evident, in this case, that the ship has crossed the equator.*

5. The difference of longitude between two places, being both east or west, is found *by subtracting the less longitude from the greater; but if one be in east longitude and the other in west, their sum is the difference of longitude, when it does not exceed 180°, but if it exceeds 180°, that sum must be subtracted from 360°, and the remainder will be the difference of longitude.*

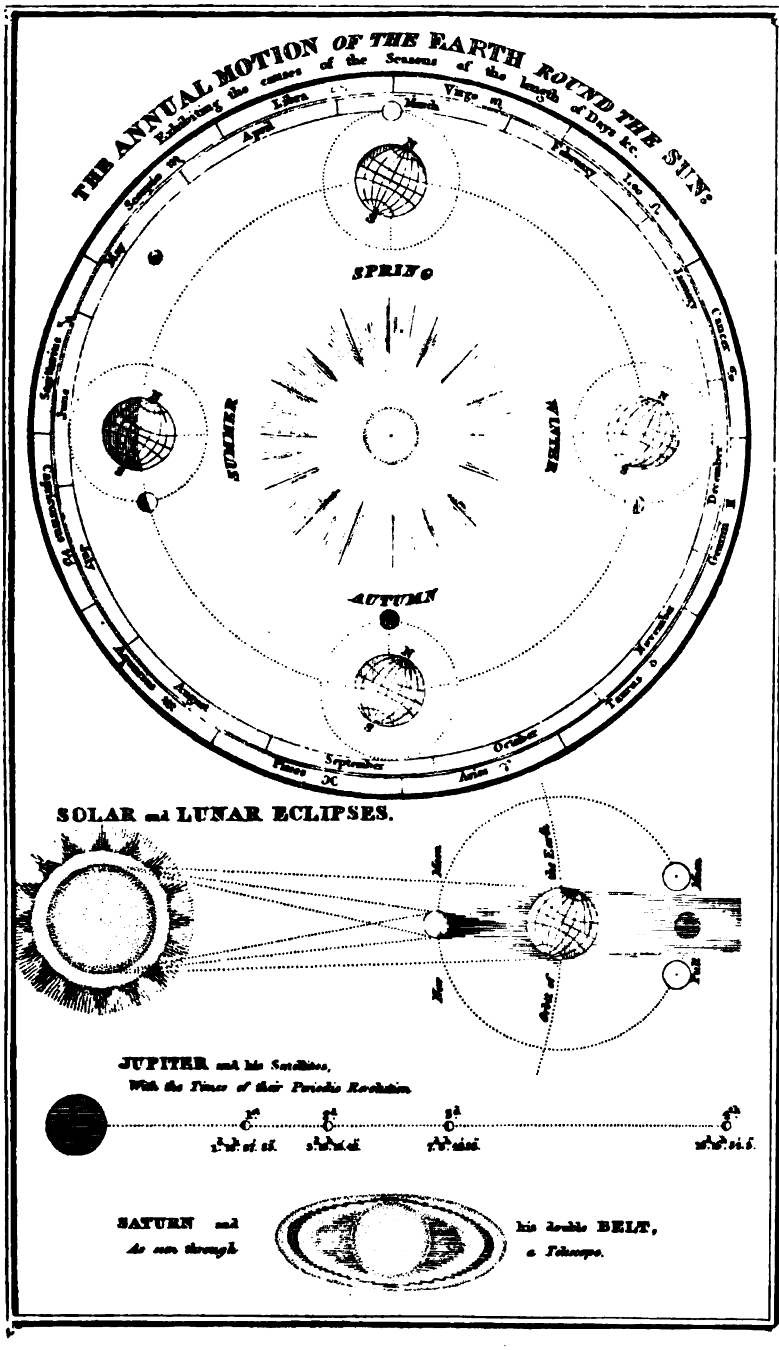
6. *Therefore in east longitude sailing easterly, or in west longitude sailing westerly, the difference of longitude, added to the longitude left, gives the longitude in,* when that sum does not exceed 180°; but if it exceeds 180°, the sum, subtracted* from 360° leaves the longitude in, but of a different name from that left.

7. *In east longitude sailing westerly, or in west longitude sailing easterly, the difference of longitude, subtracted from the longitude left, gives the longitude in; but when the difference of longitude is greatest, the longitude left must be subtracted from that difference, and the remainder will be the longitude in, but of a different name from the longitude left.*

---

*In this rule it is supposed, that the sum of the longitude left, and the difference of longitude, is less than 360°, which is always the case when the difference of longitude is less than 180°, which we have generally supposed to be the case in these rules.

Digitized by Google


THE ANNUAL MOTION OF THE EARTH ROUND THE SUN:
Exhibiting the causes of the Seasons & the length of Days &c.
SPRING
SUMMER
WINTER
AUTUMN
SOLAR and LUNAR ECLIPSES.
JUPITER and his Satellites,
With the Times of their Periodic Revolution
SATURN and his double BELT,
As seen through a Telescope.

Digitized by Google

What has been said will be rendered familiar to the learner by the following examples:—

EXAMPLE I.

What is the difference of latitude between Boston, in the latitude of 42° 21′ N., and Richmond (Virginia), in the latitude of 37° 32′ N.?

From Boston's latitude	42° 21′ N.
Subtract Richmond's latitude	37 32 N.
Remains the difference of lat.	4 49
	60
In miles	289

EXAMPLE II.

A ship from latitude 59° 27′ S., sails southward until her difference of latitude is 374 miles; what latitude is she come to?

Latitude sailed from	59° 27′ S.
Difference of lat. 374 ÷ 60 =	6 14 S.
Latitude in	65 41 S.

EXAMPLE III.

Required the difference of latitude between Georgetown and Cape Frio.

Georgetown's latitude	33° 22′ N.
Cape Frio's latitude	23 1 S.
Difference of latitude	56 23
	60
In miles	3383

EXAMPLE IV.

A ship from latitude 28° 25′ N., sails south 1800 miles; what latitude is she in?

From difference of latitude, 1800 miles, or	30° 00′ S.
Subtract latitude left	28 25 N.
Difference is the latitude in.	1 35 S.

In the last example, it is evident, that as the difference of latitude is more than the latitude left, the ship must have crossed the equator, and consequently has come into south latitude.

Note. When one of the places has no latitude, or is on the equator, the latitude of the other place is their difference of latitude.

EXAMPLE V.

What is the difference of longitude between Cape Ann light-house and Lisbon?

Cape Ann light-house's long.	70° 34′ W.
Lisbon's longitude	9 9 W.
Difference of longitude.....	61 25
	60
In miles	3685

EXAMPLE VI.

A ship from Cape Charles, in Virginia, sails eastward till her difference of longitude is 400 miles; what longitude is she in?

Cape Charles's longitude...	76° 02′ W.
Diff. of longitude, 400 miles =	6 40 E.
Longitude in	69 22 W.

EXAMPLE VII.

What is the difference of longitude between Barcelona and Salem?

Barcelona's longitude......	2° 11′ E.
Salem's longitude.........	70 54 W.
Difference of longitude	73 5 W.

EXAMPLE VIII.

A ship from 15° 40′ E. longitude, sails westward till her difference of longitude is 27° 15′; what longitude is she in?

Longitude left............	15° 40′ E.
Difference of longitude	27 15 W
Longitude in	11 35 W.

EXAMPLE IX.

What is the difference of longitude between Manilla and New York light-house?

Manilla's longitude.......	121° 02′ E.
New York light-house....	74 01 W.
Sum exceeds 180°	195 03
Subtract it from	360 00
Difference of longitude ...	164 57

EXAMPLE X.

A ship from longitude 160° 20′ W., sails westward until she differs her longitude 41° 20′; what longitude is she in?

Longitude left...........	160° 20′ W
Difference of longitude ...	41 20 W
	201 40
	360 00
Longitude in	158 20 E.

In the last example, the ship has crossed the opposite meridian, and therefore has come into a longitude of a different name

Digitized by Google

PLANE SAILING.

PLANE SAILING is the art of navigating a ship upon principles deduced from the supposition of the earth's being an extended plane, on which the meridians are all parallel to each other. A map of the several parts of the earth, constructed upon these principles, is called a PLANE CHART. When the parts of the earth are thus delineated on a plane, it is easy to see the track by which a ship may go from one place to another, and also what angle this track makes with the meridian.* Ships at sea are kept in this tract by means of an instrument called the *mariner's compass*.

The MARINER'S COMPASS is an artificial representation of the horizon of any place. It consists of a circular piece of paper (see Plate VI. fig. 1), called a card, divided (like the horizon) into 360 degrees, or 32 points. This is fixed on a piece of steel, called a needle, to which the magnetic virtue has been communicated by means of a loadstone, which has the property of pointing steadily towards the north, and carrying the card with it, when turning freely on a pivot or any thing to support it. Thus all the points of the card will be directed towards their corresponding points of the horizon; † consequently, by help of the compass, a ship may be kept in any proposed track or course.

The COURSE is the angle which the line described by a ship makes with the meridian, being sometimes reckoned in points, half points, &c., and sometimes in degrees.

DISTANCE is the way or length a ship has gone on a direct course in a given time. The method of measuring this distance by the log will be explained hereafter.

DIFFERENCE OF LATITUDE is the distance which the ship has made north or south of the place sailed from, or the portion of the meridian contained between the parallels of latitude sailed from and come to.

DEPARTURE is the east or west distance a ship has made from the meridian, or the whole easting or westing made by the ship.

If a ship sails due north or south, she sails on a meridian, makes no departure, and her distance and difference of latitude are the same. If she sails due east or west, she goes on a parallel of latitude, makes no difference of latitude, and her departure and distance are the same.

The difference of latitude and the departure make the legs of a right-angled triangle, the hypotenuse of which is the distance the ship has sailed; the perpendicular is the difference of latitude counted on the meridian; the base is the departure, which is easting or westing counted from the meridian; the angle opposite to the base is the course, or angle that the ship makes with the meridian; and the angle opposite the perpendicular is the complement of the course, which being taken together, make always 8 points or 90 degrees.

In constructing figures relating to a ship's course, let the upper part of the paper, or what the figure is drawn upon, always represent the north; the lower part will be the south; the right hand east, and the left west.

Draw the north and south line to represent the meridian of the place the ship sails from; then, if the ship's course is to the southward, mark the upper end of the line for the place sailed from; but if the course is northward, mark the lower end for that place.

When the course is easterly, describe the arc, and lay off the course and departure on the right-hand side of the meridian; but when westerly, on the left-hand side.

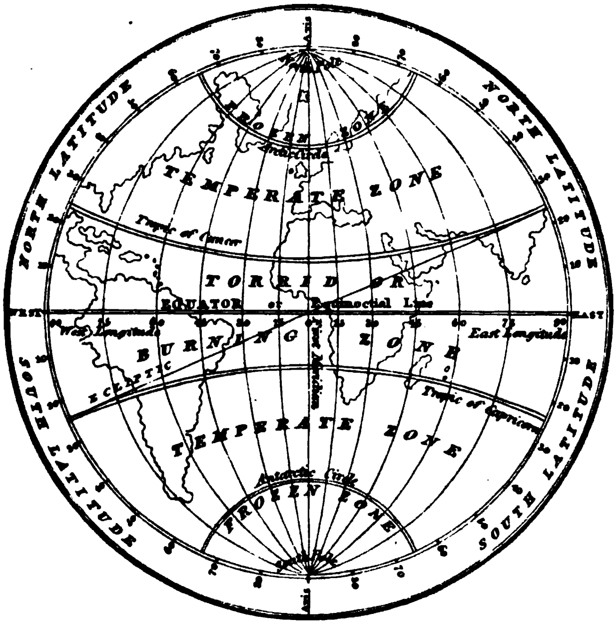
When the course is given in degrees, they must be taken from the protractor, or from the line of chords; but when in points, from the line of rhumbs, and must always be laid off upon the arc, beginning at the meridian.

* The method of calculating this angle on the true principles of sailing on the spherical surface of the earth, will be given hereafter.

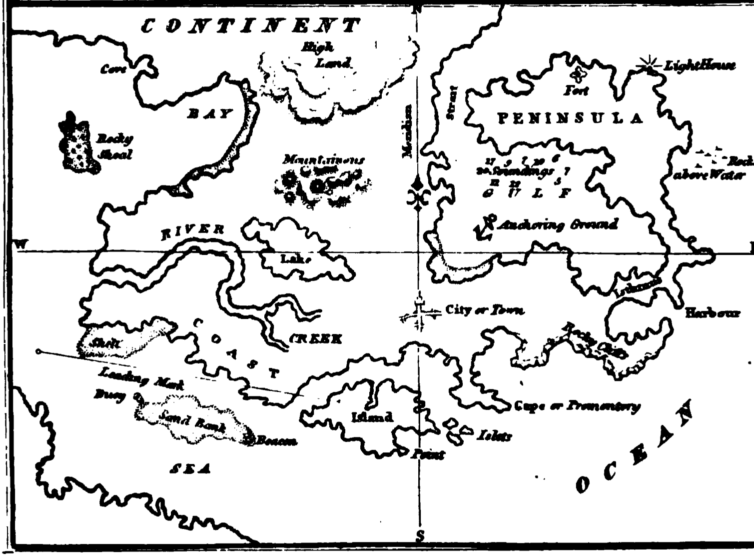
† It is here supposed that the needle points to the true north, but if it varies therefrom, allowance must be made for the variation by the rules which will be given in this work.

Digitized by Google

THE CIRCLES, ZONES, &C: OF
THE ARTIFICIAL GLOBE OR SPHERE



EXPLANATION OF GEOGRAPHICAL TERMS.



Digitized by Google

When the course is given in points, the log. sine, log. cosine, &c., may be found in Table XXV., otherwise in Table XXVII.

In all cases, where the complement of course, or cosine, &c. is used, the degrees or points put down are the course itself, but the logarithms belonging to the complement or cosine, &c., of that course are taken.

A Table of the Angles which every Point of the Compass makes with the Meridian.

North.	South.	Points.	D.M.	North.	South.
		¼	2.49		
		½	5.37		
		¾	8.26		
N. by E.	S. by E.	1	11.15	N. by W.	S. by W.
		1¼	14. 4		
		1½	16.52		
		1¾	19.41		
N. N. E.	S. S. E.	2	22.30	N. N. W.	S. S. W.
		2¼	25.19		
		2½	28. 7		
		2¾	30.56		
N. E. by N.	S. E. by S.	3	33.45	N. W. by N.	S. W. by S.
		3¼	36.34		
		3½	39.22		
		3¾	42.11		
N. E.	S. E.	4	45. 0	N. W.	S. W.
		4¼	47.49		
		4½	50.37		
		4¾	53.26		
N. E. by E.	S. E. by E.	5	56.15	N. W. by W.	S. W. by W.
		5¼	59. 4		
		5½	61.52		
		5¾	64.41		
E. N. E.	E. S. E.	6	67.30	W. N. W.	W. S. W.
		6¼	70.19		
		6½	73. 7		
		6¾	75.56		
E. by N.	E. by S.	7	78.45	W. by N.	W. by S.
		7¼	81.34		
		7½	84.22		
		7¾	87.11		
	East.	8	90. 0	West.	

In the following Table, the Rules for solving the various Cases of Plane Sailing are collected.

PLANE SAILING.

Case.	Given.	Required.	Solutions.
1	Course and distance.	Diff. of latitude. Departure.	Radius : distance : : cos. course : difference of latitude. Radius : distance : : sine course : departure.
2	Course and diff. of latitude.	Distance. Departure	Cosine course : diff. of latitude : : radius : distance. Radius : diff. of latitude : : tang. course : departure.
3	Course and departure.	Distance. Diff. of latitude.	Sine course : departure : : radius : distance. Radius : departure : : cotang. course : diff. of latitude.
4	Distance and diff. of latitude.	Course. Departure.	Distance : radius : : diff. of latitude : cos. course. Radius : distance : : sine course : departure.
5	Distance and departure.	Course. Diff. of latitude.	Distance : radius : : departure : sine course. Radius : distance : : cos. course : diff. of latitude.
6	Diff. of latitude and departure.	Course. Distance	Diff. of latitude : radius : : departure : tang. course. Sine course : departure : : radius : distance. Radius : diff. of latitude : : secant course : distance.

Digitized by Google

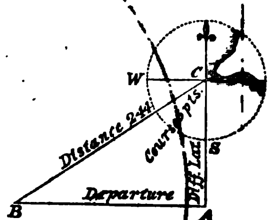
CASE I.

Course and distance sailed given, to find the difference of latitude and departure from the meridian.

A ship from the latitude of 49° 57′ N., sails S. W. by W. 244 miles; required the latitude she is in, and her departure from the meridian sailed from.

BY PROJECTION.

Draw the line CA, to represent the meridian of the place C, from whence the ship sailed. With the chord of 60° in your compasses, and one foot in C, as a centre, describe the compass W. S. E. Take 5 points in your compasses from the line of rhumbs on the plane scale, and set it off on the arc, from S. towards W., for the course; through this point and C draw the line CB, and make it equal to the distance 244; draw BA parallel to the east and west line EW, to cut the meridian in A. Then will CA be the difference of latitude 135.6, and AB the departure 202.9.



BY LOGARITHMS.

By making the distance radius.

To find the departure.		To find the difference of latitude.	
As radius 8 points............	10.00000	As radius 8 points............	10.00000
Is to the distance 244	2.38739	Is to the distance 244	2.38739
So is the sine course 5 points ..	9.91985	So is the cosine course 5 points.	9.74474
To the departure 202.9........	2.30724	To the difference of lat. 135.6..	2.13213

Now, as the ship is in north latitude sailing southerly,

From the latitude left	49° 57′ N.
Take the difference of latitude 135.6....................	2 16 S.
Gives the latitude in..	47 41 N.

And the departure from the meridian is 202.9 miles.

BY GUNTER.

Extend from radius or 8 points* to 5 points on the line marked SR; that extent will reach from the distance 244, to the departure 202.9, on the line of numbers.

2dly. Extend from radius or 8 points to 3 points, the complement of the course, on the line SR; that extent will reach from the distance 244, to the difference of latitude 135.6, on the line of numbers.

Thus may all the operations be performed in the several cases of Navigation.

By this case are calculated the tables of latitude and departure (Tables I. and II.) for every degree, point, and quarter point of the mariner's compass, to the distance of 300 miles. By the inspection of these tables, a day's work may be calculated in a much more expeditious manner than by logarithms or by Gunter's scale. In consequence of this facility, the method by inspection is generally used at sea in preference to every other method.

BY INSPECTION.

Find the given course at the top or bottom of the tables, either among the points or degrees, and in that page, against the distance taken in its column, will stand the difference of latitude and departure in their columns.†

It must be observed, that, in using these tables, the names Dist. Lat. Dep. must be found at the top if the course is found there, but if the course is found at the bottom, those names must be found at the bottom.

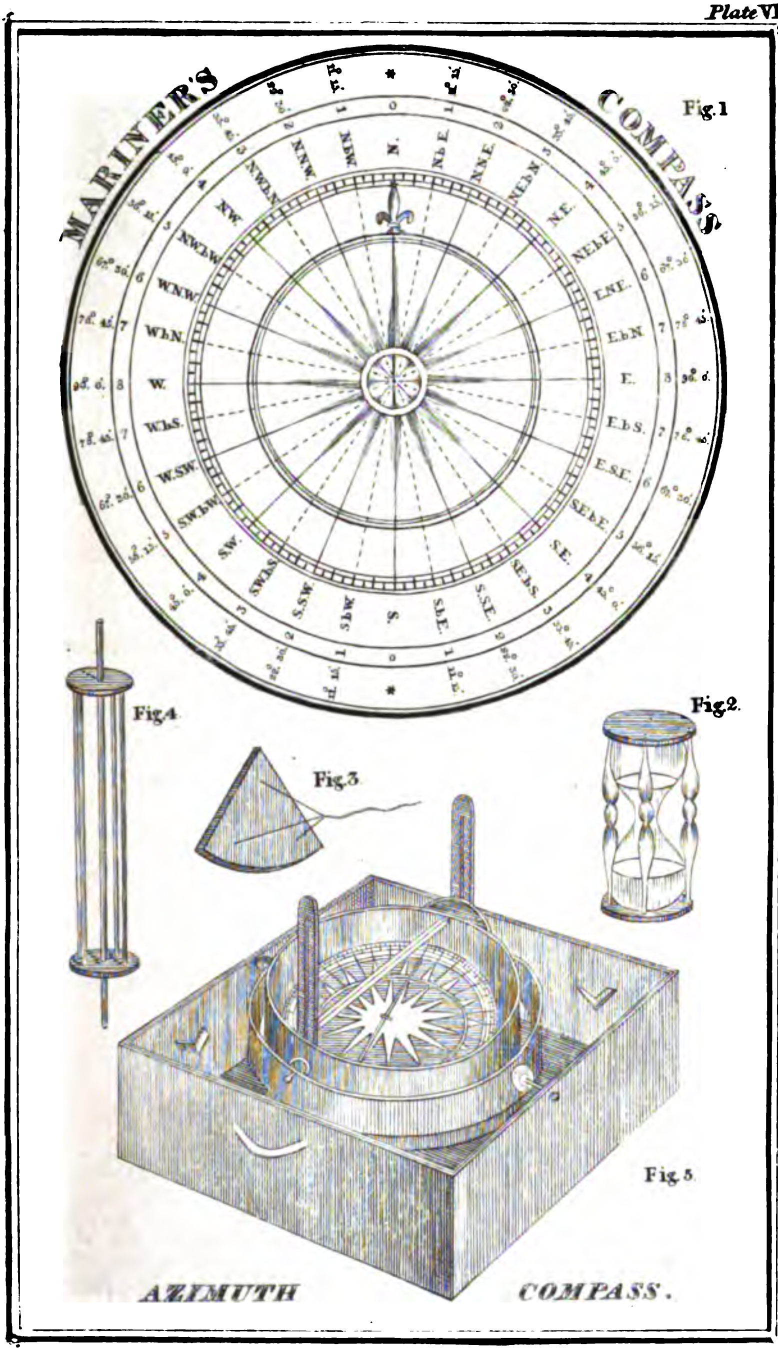
Thus the course S. W. by W. or 5 points, is found at the bottom of the table of difference of latitude and departure for points; and against 244 in the distance column stands 135.6 for the difference of latitude, or 202.9 for the departure.

* When the course is given in points, make use of the lines marked *sine rhumbs*, and *tangent rhumbs* on the upper side of the scale; when in degrees, make use of the lines marked *sine* and *tangent*.

† When the distance is too great to be found in the tables, you must divide it by 2, 3, 4, or any convenient number; the numbers corresponding to the quotient being multiplied by the divisor will give the sought numbers.

Digitized by Google

Plate VI.



Digitized by Google

Digitized by Google

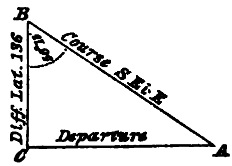
CASE II.

Course and difference of latitude given, to find the distance run, and departure from the meridian.

A ship runs S. E. by E. from 1° 45′ north latitude, and then, by observation, is in 0° 31′ south latitude; required her distance and departure.

In this case, as the ship has crossed the equator, the sum of the two latitudes, 1° 45 and 0° 31′, is the difference of latitude, 2° 16′ = 136 miles.

BY PROJECTION.



Draw BC equal to 136, and BA making an angle with BC equal to the course 5 points, or 56° 15′; draw CA perpendicular to BC to cut BA in A, and it is done; for CA will be the departure equal to 203.5, and AB the distance equal to 244.8.

BY LOGARITHMS.

By making the difference of lat. BC radius. To find the departure.		By making the distance AB radius.* To find the distance.	
As radius 4 points............	10.00000	As cosine course 5 points......	9.74474
Is to difference of latitude 136..	2.13354	Is to the difference of latitude 136	2.13354
So is tangent course 5 points...	10.17511	So is radius	10.00000
To the departure 203.5........	2.30865	To the distance 244.8.........	2.38880

Hence the ship's distance run is 244.8 miles, and her departure from the meridian is 203.5 easterly.

BY GUNTER.

Extend from radius or 4 points to the course 5 points on the line marked TR; that extent will reach from the difference of latitude 136, to the departure 203.5, on the line of numbers.

2dly. Extend from the complement of the course 3 points to the radius 8 points on the line SR; that extent will reach from the difference of latitude 136, to the distance 244.8, on the line of numbers.

BY INSPECTION.

Find the course among the points or degrees, and the difference of latitude in its column, against which will stand the distance and departure in their columns.

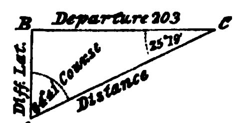
CASE III.

Course and departure from the meridian given, to find the distance and difference of latitude.

If a ship sails N. E. by E. ¾ E. from a port in 3° 15′ south latitude, until she depart from her first meridian 203 miles, required the distance sailed, and the latitude she is in.

BY PROJECTION.

Draw the meridian AB, upon which erect the perpendicular BC, and set off thereon the departure 203, easterly from B to C; with the chord of 60° on C, as a centre, describe an arc, and set off thereon the complement of the course; through this point and C draw the line CA, cutting the meridian in the point A; then AC measured on the same scale before used, gives the distance 224.6, and AB 96, the difference of latitude.



---

* By making BC radius, you would have, radius : difference of latitude :: secant course : distance but this canon would not do for a common scale on which there is no line of secants. The same thing is to be observed in the following cases

Digitized by Google

BY LOGARITHMS.

By making the departure BC radius.		By making the distance AC radius.	
As radius 4 points	10.00000	As sine course $5\frac{3}{4}$ points	9.95616
Is to the departure 203	2.30750	Is to the departure 203	2.30750
So is cotangent course $5\frac{3}{4}$ points	9.67483	So is radius	10.00000
To the difference of latitude 96.	1.98233	To the distance 224.6	2.35134

From the latitude left	3° 15′ S.
Subtract the difference of latitude 96 miles, or	1 36 N.
The remainder shows that the ship is in the latitude of	1° 39′ S.

BY GUNTER.

Extend from radius or 4 points to the complement of the course $2\frac{1}{4}$ points on the line marked TR; that extent will reach from the departure 203, to the difference of latitude 96, on the line of numbers.

2dly. Extend from the course $5\frac{3}{4}$ points to radius on the line SR; that extent will reach from the departure 203, to the distance 224.6 miles, on the line of numbers.

BY INSPECTION.

Find the course, either among the points or degrees, and the departure in its column, against which will stand the distance and difference of latitude in their respective columns.

Thus with the course $5\frac{3}{4}$ points, and departure 203, we find 224.6 for the distance, and 96.0 for the difference of latitude.

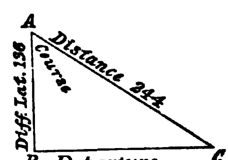
CASE IV.

Distance and difference of latitude given, to find the course and departure

Suppose a ship sails 244 miles, between the south and the east, from a port in 2° 52 south latitude, and then, by observation, is in 5° 08′ south latitude; what course has she steered, and what departure has she made?

From the latitude by observation 5° 08′, take 2° 52′, the latitude left; the remainder, 2° 16′ = 136 miles, is the difference of latitude.

BY PROJECTION.



Draw the meridian AB = 136; upon which erect the perpendicular BC; take 244 in your compasses, and with one foot on A, as a centre, describe an arc cutting BC in C; join A and C; then will BC be the departure 202.6, and the angle BAC the course, equal to 56° 08′, or 5 points, nearly.

BY LOGARITHMS.

To find the course.		To find the departure	
As the distance 244	2.38739	As radius	10.00000
Is to radius	10.00000	Is to the distance 244	2.38739
So is the difference of lat. 136..	2.13354	So is the sine course 56° 08′	9.91925
To cosine course 56° 08′	9.74615	To the departure 202.6	2.30664

Hence the course is S. E. by E., and the departure 202.6.

BY GUNTER.

The extent from the distance 244, to the difference of latitude 136, on the line of numbers, will reach from radius or 90° to 33° 52′, the complement of the course on the line of sines.

And the extent from radius, to 56° 08′ on the line of sines, will reach from the distance 244, to the departure 202.6, on the line of numbers.

BY INSPECTION.

Seek in the tables till against the distance, taken in its column, is found the given difference of latitude in one of the following columns; adjoining to it will stand the

depart..re; which if less than the difference of latitude, the course is to be found at the top;* but if greater, the course is to be found at the bottom.

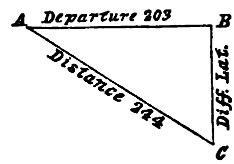
Thus the distance 244, and the difference of latitude 136, are found to correspond to a course of 5 points, or S. E. by E., and to the departure 202.9, nearly.

CASE V.

Distance and departure given, to find the course and difference of latitude.

Suppose a ship sails 244 miles between the north and west, from the latitude of 32° 25′ north, until her departure is 203 miles; what course has she steered, and what latitude is she in?

BY PROJECTION.



Draw the line AB equal to the departure 203; and, perpendicular thereto, the line BC, to represent the meridian; then take the distance 244 in your compasses, and, fixing one foot in A, as a centre, describe an arc, cutting BC in C; join AC, and it is done; for the angle ACB will be the course, and BC the difference of latitude

BY LOGARITHMS.

To find the course.		To find the difference of latitude.	
As the distance 244	2.38739	As radius	10.00000
Is to radius..................	10.00000	Is to the distance 244	2.38739
So is the departure 203	2.30750	So is cosine course 56° 18′	9.74417
To the sine of course 56° 18′...	9.92011	To the difference of lat. 135.4..	2.13156

Hence the course is N. 56° 18′ W., or N. W. by W. nearly.

To the latitude sailed from 32° 25′ add the difference of latitude 135 or 2° 15′; the sum 34° 40′ is the latitude the ship is in.

BY GUNTER.

Extend from the distance 244, to the departure 203, on the line of numbers; that extent will reach from radius to the course 56° 18′ on the line of sines.

2dly. Extend from radius to the complement of the course 33° 42′, on the line of sines; that extent will reach from the distance 244, to the difference of latitude 135.4, on the line of numbers.

BY INSPECTION.

Seek in the tables till against the distance taken in its column is found the given departure in one of the following columns; adjoining to it will stand the difference of latitude; and if it be greater than the departure, the course is to be found at the top; but if less, the course is to be found at the bottom.

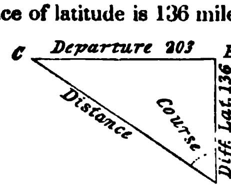
Thus the distance 244, and the departure 203, agree to a course of 5 points, or N. W. by W., and a difference of latitude 135.6 miles, nearly.

CASE VI.

Difference of latitude and departure given, to find the course and distance.

A ship sails between the north and west till her difference of latitude is 136 miles, and her departure is 203 miles; required her course and distance.

BY PROJECTION.



Draw AB = 136, and perpendicular to it BC = 203; join C and A; then will the angle CAB be the course 56° 11′, and AC the distance 244.4 miles.

* It may also be known whether the course be marked at the top or bottom of the table, by observing whether the difference of latitude and departure correspond with the marks at the top or bottom. Thus the distance 244, and difference of latitude 136, correspond to the course 5 points, because the column in which 136 is found, is marked *latitude* at the bottom; the same may be observed in the following cases

Digitized by Google

BY LOGARITHMS.

To find the course.		To find the distance.	
As the difference of latitude 136	2.13354	As radius	10.00000
Is to radius....................	10.00000	Is to the difference of lat. 136..	2.13354
So is the departure 203	2.30750	So is secant of course 56° 11′ ..	10.25451
To tangent of course 56° 11′...	10.17396	To the distance 244.4.........	2.38805

Hence her course is N. 56° 11′ W., or N. W. by W., and the distance sailed is 244.4 miles.

BY GUNTER.

Extend from the difference of latitude 136, to the departure 203, on the line of numbers; that extent will reach from radius to 56° 11′, the course on the line of tangents.

2dly. For the distance we must consider it as radius (unless there is a line of secants on the scale), and extend from the course 56° 11′, to the radius, or 90°, on the line of sines; that extent will reach from the departure 203, to the distance 244.4, on the line of numbers.

BY INSPECTION.

Seek in the tables till the given difference of latitude and departure are found together in their respective columns; then against them will be the distance in its column, and the course will be found at the top of that table if the departure be less than the difference of latitude, otherwise at the bottom.

Thus with the difference of latitude 136, and the departure 203, enter the tables, and these numbers will be found to correspond nearly to 5 points, or N. W. by W. course, and a distance equal to 244 miles.

QUESTIONS

To exercise the learner in the foregoing rules.

Question I. A ship in 2° 10′ south latitude, sails N. by E. 89 leagues; what latitude is she in, and what is her departure?

Answer. Latitude in 2° 12′ N., and departure 17.36 leagues.

Quest. II. A ship sails S. S. W. from a port in 41° 30′ north latitude, and then, by observation, is in 36° 57′ north latitude; required the distance run, and departure.

Ans. Distance run 98.5 leagues, departure 37.7 leagues.

Quest. III. A ship sails S. S. W. ½ W. from a port in 2° 30′ south latitude, until her departure be 59 leagues; required the distance run, and latitude in.

Ans. Distance run 125.2 leagues, latitude in 8° 1′ south.

Quest. IV. If a ship sails 360 miles south-westward from 21° 59′ south latitude, until by observation she be in 24° 49′ south latitude, what is her course and departure?

Ans. The course is S. W. by W. ½ W., or S. 61° 49′ W., and her departure from the meridian is 317.3 miles.

Quest. V. Suppose a ship sails 354 miles north-eastward from 2° 9′ south latitude, until her departure be 150 miles, what is her course and latitude in?

Ans. Her course is N. 25° 4′ E., or N. N. E. ¼ E. nearly, and she is in lat. 3° 12′ N.

Quest. VI. Sailing between the north and the west, from a port in 1° 59′ south latitude, and then arriving at another port in 4° 8′ north latitude, which is 209 miles to the westward of the first port, required the course and distance from the first port to the second.

Ans. The course is N. 29° 40′ W., or N. N. W. ¾ W. nearly, and the distance of the ports is 422.4 miles, or 140.8 leagues.

Quest. VII. Four days ago we were in latitude 3° 25′ S., and have since that time sailed in a direct course N. W. by N. at the rate of 8 miles an hour; required our present latitude and departure.

Ans. Latitude in 7° 14′ N., departure 426.7 miles.

Quest. VIII. A ship in the latitude of 3° 52′ south, is bound to a port bearing N. W. by W. ½ W in the latitude of 4° 30′ north; how far does that port lie to the westward, and what is the ship's distance from it?

Ans. The port lies 939.2 miles to the westward, and the direct distance is 1065 miles.

Quest. IX. A ship from the latitude of 48° 17′ N., sails S. W. by S. until she has depressed the north pole 2 degrees; what direct distance has she sailed, and how many miles has she sailed to the westward?

Ans. Distance run 144.3 miles, and has sailed to the westward 80.2 miles.

Digitized by Google

TRAVERSE SAILING.

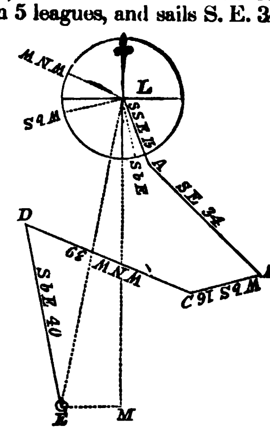
A TRAVERSE is an irregular track which a ship makes by sailing on several different courses; these are reduced to a single course by means of two or more cases of Plane Sailing, either by geometrical construction, or by arithmetical calculation.*

The geometrical construction is performed as follows:—Describe a circle with the chord of 60°, to represent the compass, and lay off on its circumference the various courses sailed. From the centre, upon the first course, set off the first distance, and mark its extremity; through this extremity, and parallel to the second course, draw the second distance of its proper length; through the extremity of the second distance, and parallel to the third course, draw the third distance of its proper length; and thus proceed till all the distances are drawn. A line, drawn from the extremity of the last distance to the centre of the circle, will represent the distance made good; a line, drawn from the same point, perpendicular to the meridian, will represent the departure, and the part of the meridian intercepted between this and the centre, will represent the difference of latitude.

The arithmetical calculation to work a traverse is as follows:—Make a traverse table consisting of six columns; title them, Course, Distance, N., S., E., W.; begin at the left side, and write the given courses and distances in their respective columns. Find the difference of latitude and departure for each of these courses, by Gunter's scale, or by Tables I. or II. (as in Case I. Plane Sailing), and write them in their proper columns; that is, when the course is southerly, the difference of latitude must be set in the column S.; when northerly, in the column N.: the departure, when westerly, in the column W.; and when easterly, in the column E. Add up the columns of northing southing, easting, and westing; take the difference between the northing and southing, and also between the easting and westing; the former difference will be the difference of latitude, which will be of the same name as the greater; and the latter will be the departure, which will be also of the same name as the greater. With this difference of latitude and departure the course and distance made good are to be found as in Case VI. Plane Sailing.

EXAMPLE I.

Suppose a ship takes her departure from Block Island, in the latitude of 41° 10′ N., the middle of it bearing N. N. W., distance by estimation 5 leagues, and sails S. E. 34 W. by S. 16, W. N. W. 39, and S. by E. 40 miles; required the latitude she is in, and her bearing and distance from Block Island.



BY PROJECTION.

Let L represent the middle of Block Island; draw the meridian LM, and on L, as a centre, with a chord of 60°, describe a circle to represent the compass, on which mark the various courses sailed, and the bearing of the land at the time of taking the departure; opposite to this bearing draw the S. S. E. line LA, which make equal to 15 miles, the estimated distance of the land; then will A represent the place of the ship at the time of taking the departure: through A draw AB equal 34 miles, parallel to the S. E. line; then will B be the place of the ship after sailing her first course: in like manner draw BC equal to 16 miles, parallel to the W. by S. line; CD equal to 39 miles, parallel to

* This method of reducing compound courses to a single one is perfectly accurate in sailing on a plane, and is nearly so in sailing a short distance on the spherical surface of the earth; and though in this case it is liable to a small error in high latitudes, yet in general the rule is sufficiently accurate for reducing the several courses and distances sailed in one day to a single course and distance.

the W. N. W. line, and DE equal to 40 miles, parallel to the S. by E. line; then will E represent the place of the ship after sailing her several courses. Join EL, and draw EM perpendicular to LM; then will LE be the distance of Block Island, 66.8 miles; and the angle ELM = 12° 16′, will be the course made good; LM the difference of latitude, and EM the departure.

TO FIND THE SAME BY LOGARITHMS.

For the first course S. S. E. 15 miles.

To find the difference of latitude.		For departure.	
As radius 90°	10.00000	As radius 90°	10.00000
Is to cosine course 2 points	9.96562	Is to sine course 2 points	9.58284
So is distance 15	1.17609	So is distance 15	1.17609
To difference of latitude 13.9	1.14171	To departure 5.7	0.75893

Second course S. E. 34 miles.

For difference of latitude.		For departure.	
As radius 90°	10.00000	As radius 90°	10.00000
Is to cosine course 45°	9.84949	Is to sine course 45°	9.84949
So is distance 34	1.53148	So is distance 34	1.53148
To difference of latitude 24	1.38097	To departure 24	1.38097

Third course W. by S. 16 miles.

For difference of latitude.		For departure.	
As radius 90°	10.00000	As radius 90°	10.00000
Is to cosine course 78° 45′	9.29024	Is to sine course 78° 45′	9.99157
So is distance 16	1.20412	So is distance 16	1.20412
To difference of latitude 3.1	0.49436	To departure 15.7	1.19569

Fourth course W. N. W 39 miles.

For difference of latitude.		For departure.	
As radius 90°	10.00000	As radius 90°	10.00000
Is to cosine course 67° 30′	9.58284	Is to sine course 67° 30′	9.96562
So is distance 39	1.59106	So is distance 39	1.59106
To difference of latitude 14.9	1.17390	To departure 36	1.55668

Fifth course S. by E. 40 miles.

For difference of latitude.		For departure.	
As radius 90°	10.00000	As radius 90°	10.00000
Is to cosine course 11° 15′	9.99157	Is to sine course 11° 15′	9.29024
So is distance 40	1.60206	So is distance 40	1.60206
To difference of latitude 39.2	1.59363	To departure 7.8	0.89230

Though this method of finding the difference of latitude and departure by logarithms is accurate, yet the calculations may be more easily made by the tables of difference of latitude and departure, as in Case I. Plane Sailing.

Place all these courses, distances, &c., in the traverse table; then add up all the westings, eastings, northings, and southings, separately, and set down their respective sums at the bottom of each column; and as the westing is greater than the easting, subtract the easting therefrom; the difference, 14.2, shows that the ship's departure is so much west of her first meridian.

TRAVERSE TABLE.

Courses.	*Dist.*	*Diff. of Lat.* N.	*Diff. of Lat.* S.	*Departure.* E.	*Departure.* W.
S. S. E.	15		13.9	5.7	
S. E.	34		24.0	24.0	
W. by S.	16		3.1		15.7
W. N. W.	39	14.9			36.0
S. by E	40		39.2	7.8	
		14.9	80.2	37.5	51.7
From sum take			14.9		37.5
Remainder			65.3		14.2

Again, the southing being greater than the northing, subtract the northing from it, and the remainder, 65.3, shows how far the ship is to the southward of her first place

Digitized by Google

To find the direct course or bearing of Block Island from the ship.

As the difference of latitude 65.3	1.81491
Is to radius 45°	10.00000
So is the departure 14.2	1.15229
To tangent course 12° 16′	9.33738

Which, because the difference of latitude is southerly, and the departure westerly, is S. 12° 16′ W. Whence Block Island bears from the ship N. 12° 16′ E., or N. by E. 1° 1′ E

To find the distance of the island.

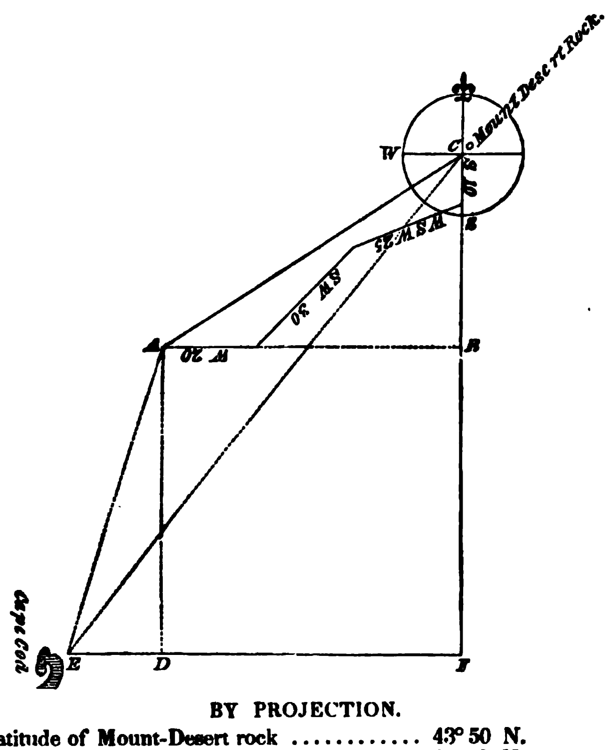
As sine of course 12° 16′	9.32728
Is to the departure 14.2	1.15229
So is radius 90°	10.00000
To the distance 66.8	1.82501

BY INSPECTION.

Find the course and distance by Case VI of Plane Sailing.

EXAMPLE II.

A ship from Mount-Desert rock, in the latitude of 43° 50′ N., sails for Cape Cod, in the latitude of 42° 3′ N., its departure from the meridian of Mount-Desert rock being supposed to be 84 miles west; but by reason of contrary winds, she is obliged to sail on the following courses, viz. south 10 miles, W. S. W. 25 miles, S. W. 30 miles, and W. 20 miles. Required the bearing and distance of the two places, the course and distance sailed by the ship, and the bearing and distance of her intended port.



BY PROJECTION.

Latitude of Mount-Desert rock	43° 50 N.
Latitude of Cape Cod	42 3 N.
Difference of latitude	1 47 = 107 miles.

Let C represent Mount-Desert rock; draw the meridian CF, which make equal to 107 miles, the difference of latitude between the two places, and perpendicular thereto the line FE, equal to the departure, 84 miles; then is E the place of Cape Cod. With the chord of 60° sweep about the centre, C, a circle, S. W., to represent the compass, and upon it note the various courses sailed. The first course being south, the distance, 10 miles, is set off from C towards F upon the meridian, and this point represents the place of the ship after sailing her first course; continue setting off the various courses and distances as in the last example, viz. W. S. W. 25 miles, S. W. 30 miles, and west 20 miles to the point A; then will A represent the place of the ship after

sailing these courses. Join CE, AC, AE; draw AB perpendicular to the meridian CF, and AD parallel thereto; then will AC = 76.2 miles be the distance made good; AE = 69.1 miles, the distance of Cape Cod from the ship; CE the distance of the two places = 136 miles; ACB = 57° 36′, the course made good; EAD = 16° 34′, the course to Cape Cod; and ECF the course from Mount-Desert rock to Cape Cod = 38° 8′, &c

BY LOGARITHMS.

To find the bearing and distance of the two places by Case VI. Plane Sailing.

To find the bearing.		To find the distance.	
As difference of latitude 107...	2.02938	As radius 90°................	10.00000
Is to radius 45°	10.00000	Is to difference of latitude 107 .	2.02938
So is departure 84............	1.92428	So is secant course 38° 8′......	10.10426
To tangent course 38° 8′	9.89490	To the distance 136	2.13364

Whence the course from Mount-Desert rock to Cape Cod is S. 38° 8′ W., distance 136 miles. The same may be found by the scale, or by inspection.

The difference of latitude and departure for the several courses being calculated, by Case I. Plane Sailing, and arranged in the traverse table, it appears that the difference of latitude made good by the ship is 40.8 miles, and the departure 64.3 miles; then, by Case VI. Plane Sailing, these numbers are found to correspond to a course of S. 57° 36′ W. and distance 76.2 miles.

TRAVERSE TABLE.

Courses.	Dist.	Diff. of Lat.		Departure.	
		N.	S.	E.	W.
South.	10		10.0		
W. S. W.	25		9.6		23.1
S. W.	30		21.2		21.2
W.	20				20.0
		Diff. of lat.	40.8	Depart.	64.3

Subtract the difference of latitude made good by the ship, 40.8 miles, from the whole difference of latitude, 107 miles, and there remain 66.2 miles, which is the difference of latitude between the ship and Cape Cod. In the same manner, by subtracting the ship's departure, 64.3 miles, from the whole departure, 84 miles, there remain 19.7 miles for the departure between the ship and Cape Cod. With this difference of latitude 66.2, and departure, 19.7, the bearing of Cape Cod is found, by Case VI. Plane Sailing S. 16° 34′ W., and its distance, 69.1 miles.

All the preceding calculations may be made by logarithms, by the scale, or by inspection. But we shall leave them to exercise the learner, and for the same purpose shall add the following example.

EXAMPLE III.

A ship in the latitude of 37° 10′ N., is bound to a port in the latitude of 33° 0′ N., which lies 180 miles west of the meridian of the ship; but by reason of contrary winds, she sails the following courses, viz. S. W. by W. 27 miles, W. S. W. ½ W. 30 miles, W. by S. 25 miles, W. by N. 18 miles, S. S. E. 32 miles, S. S. E. ¾ E. 27 miles, S. by E. 25 miles, S. 31 miles, and S. S. E. 39 miles. Required the latitude the ship is in, and her departure from the meridian, with the course and distance to her intended port.

The difference of latitude and departure made on each course, are given in the adjoined traverse table; hence it appears that the difference of latitude made good is 169.4 miles; the departure, 47.4 miles; and by Case VI. Plane Sailing, the course S. 15° 38′ W., and distance, 175.9 miles; and the course to the intended port, S. 58° 42′ W., distance 155.2 miles; the latitude being in 34° 21′ N.

TRAVERSE TABLE.

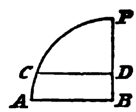
Courses.	Dist.	Diff. of Lat.		Departure.	
		N.	S.	E.	W
S. W. by W.	27		15.0		22.4
W. S. W. ½ W.	30		8.7		28.7
W. by S.	25		4.9		24.5
W. by N.	18	3.5			17.7
S. S. E.*	32		29.6	12.2	
S. S. E. ¾ E.	27		23.2	13.9	
S. by E.	25		24.5	4.9	
South.	31		31.0		
S. S. E.*	39		36.0	14.9	
		3.5	172.9	45.9	93.3
			3.5		45.9
		Diff. of lat.	169.4	Depart.	47.4

* Instead of putting the course S. S. E. 32 miles, and S. S. E. 39 miles, you might make one entry only, calling it S. S. E. 71 miles.

Digitized by Google

PARALLEL SAILING.

In Plane Sailing, the earth is considered as an extended plane; but this supposition is very erroneous, because the earth is nearly of a spherical figure, in which the meridians all meet at the poles; consequently the distance of any two meridians measured on a parallel of latitude (which distance is called the meridian distance) decreases in proceeding from the equator to the poles. To illustrate this, let PB represent the semi-axis of the earth, B the centre, P the pole, PCA a quadrant of the meridian, AB the radius of the equator, and CD (parallel thereto) the radius of a parallel of latitude. Then it is evident that CD will be the cosine of AC, or the cosine of the latitude of the point C, to the radius AB; now, if the quadrantal arc PCA be supposed to revolve round the axis PB, the point A will describe the circumference of the equator, and C the circumference of a parallel of latitude; and the former circumference will be to the latter as AB to CD (as may easily be deduced from *Art.* 55, Geometry), that is, as radius to the cosine of the latitude, or the point C; hence it follows, that the length of any arc of the equator intercepted between two meridians, is to the length of a corresponding arc of any parallel intercepted between the same meridians, as radius is to the cosine of the latitude of that parallel. Hence we obtain the following theorems.



THEOREM I.

The circumference of the equator is to the circumference of any other parallel of latitude, as radius is to the cosine of that latitude.

THEOREM II.

As the length of a degree of the equator is to the meridian distance corresponding to a degree on any other parallel of latitude, so is radius to the cosine of that parallel of latitude.

THEOREM III.

As radius is to the cosine of any latitude, so are the miles of difference of longitude between two meridians (or their distance in miles upon the equator) to the distance of these two meridians on that parallel of latitude in miles.

THEOREM IV.

As the cosine of any latitude is to radius, so is the length of any arc on that parallel of latitude (intercepted between two meridians) in miles to the length of a similar arc on the equator, or miles of difference of longitude.

THEOREM V.

As the cosine of any latitude is to the cosine of any other latitude, so is the length of any arc on the first parallel of latitude in miles, to the length of the same arc on the other in miles.

By means of Theorem III. the following table was calculated, which shows the meridian distance corresponding to a degree of longitude in every latitude; and may be made to answer for any degree or minute by taking proportional parts.

Digitized by Google

The following Table shows for every degree of latitude how many miles distant the two meridians are, whose difference of longitude is one degree.

Lat	Miles.	Lat.	Miles.	Lat.	Miles.	Lat.	Miles.	Lat.	Miles.
1°	59.99	19°	56.73	37°	47.92	55°	34.41	73°	17.54
2	59.96	20	56.38	38	47.28	56	33.55	74	16.54
3	59.92	21	56.01	39	46.63	57	32.68	75	15.53
4	59.85	22	55.63	40	45.96	58	31.80	76	14.52
5	59.77	23	55.23	41	45.28	59	30.90	77	13.50
6	59.67	24	54.81	42	44.59	60	30.00	78	12.47
7	59.55	25	54.38	43	43.88	61	29.09	79	11.45
8	59.42	26	53.93	44	43.16	62	28.17	80	10.42
9	59.26	27	53.46	45	42.43	63	27.24	81	9.39
10	59.09	28	52.98	46	41.68	64	26.30	82	8.35
11	58.90	29	52.48	47	40.92	65	25.36	83	7.31
12	58.69	30	51.96	48	40.15	66	24.40	84	6.27
13	58.46	31	51.43	49	39.36	67	23.44	85	5.23
14	58.22	32	50.88	50	38.57	68	22.48	86	4.19
15	57.96	33	50.32	51	37.76	69	21.50	87	3.14
16	57.68	34	49.74	52	36.94	70	20.52	88	2.09
17	57.38	35	49.15	53	36.11	71	19.53	89	1.05
18	57.06	36	48.54	54	35.27	72	18.54	90	0.00

When a ship sails east or west on the surface of the earth supposed to be spherical, she describes a parallel of latitude, and this is called *Parallel Sailing*. In this case, the distance sailed (or departure) is equal to the distance between the meridians sailed from and arrived at in that parallel; and it is easy, by Theorem IV. (preceding) to find the difference of longitude from the distance, or the distance from the difference of longitude, as will appear plain by the following examples.

CASE I.

The difference of longitude between two places in the same parallel of latitude being given, to find the distance between them.

Suppose a ship in the latitude of 49° 30′, north or south, sails directly east or west, until her difference of longitude be 3° 30′; required the distance sailed.

BY PROJECTION.

Take the sine of 90° from the plane scale, and, with one foot of the compasses on (fig. 1) as a centre, describe the arc EQ with the difference of longitude, 210 miles in the compasses, and one foot in E, as a centre, describe an arc cutting EQ in Q; join PE, PQ. Take the sine of the complement of the latitude 40° 30′ in your compasses, and with one foot in P, as a centre, describe the arc FG, cutting PE, PQ, in F, G; then the length of the chord FG being measured on the same scale of equal parts, will be the departure 136.4 miles.

Or this projection may be made in the following manner. Draw AD (fig. 2) of an indefinite length; make the angle DAC equal to the latitude 49° 30′, and AC equal to the difference of longitude 210 miles; draw CD perpendicular to AD; then will the line AD be the distance or departure required.

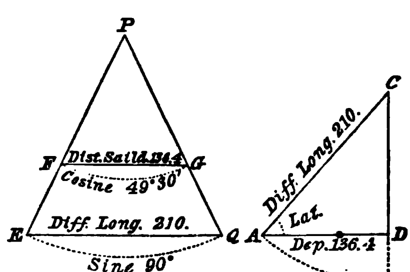


Fig. 1. Fig. 2.

BY LOGARITHMS.

To find the departure or distance.

As radius 90° 10.00000
Is to the difference of longitude 210 .... 2.32222
So is cosine latitude 49° 30′.................. 9.81254

To the distance or departure 136.4............ 2.13476

Digitized by Google

BY GUNTER

The extent from radius to the complement of the latitude 40° 30′ on the line of sines, will reach from the difference of longitude 210, to the distance 136.4, on the line of numbers.

BY INSPECTION.

Find the latitude among the degrees in Table II., and in the distance column the difference of longitude, opposite to which in the column of latitude will be the distance required.

In the present example, the latitude is 49° 30′; and as the table is only calculated to single degrees, we must find the numbers in the tables of 49° and 50°, and take the mean of them; the former is 137 8, the latter 135.0, the mean of which is the sought distance or departure, 136.4.

CASE II.

The distance between two places on the same parallel of latitude given, to find their difference of longitude.

Suppose a ship in the latitude of 49° 30′ N. or S., and longitude 36° 40′ W., sails directly west 136.4 miles; required the difference of longitude, and longitude in.

BY PROJECTION.

With the sine of the complement of the latitude, 40° 30′, in your compasses, and one foot in P, as a centre (fig. 1, of the preceding case), describe the arc FG, upon which set off the departure 136.4 miles, upon the chord FG, and through the points F and G draw the lines PE and PQ; then, with the sine of 90° in the compasses, and one foot in P, as a centre, describe an arc to cut PE, PQ, in E and Q; then the chord EQ being measured upon the same scale of equal parts that the departure was, will be the difference of longitude 210 miles.

Or thus; draw the line AD (fig. 2), which make equal to the given distance 136.4; D erect DC perpendicular to DA; make the angle DAC equal to the latitude; then will AC be the sought difference of longitude 210 miles.

BY LOGARITHMS.

As cosine of latitude 49° 30′....	9.81254	Longitude left	36° 40′ W
Is to the distance 136.4........	2.13481	Difference of longitude......	3 30 W
So is radius	10.00000	Longitude in	40 10 W
To the difference of long. 210..	2.32227		

BY INSPECTION.

Look for the latitude among the degrees, as if it was a course, and the departure in the column of latitude; against which will stand the difference of longitude in the distance column.

Thus, in the course 49°, we must seek for 136.4 in the latitude column, and we find it corresponds to the distance 208; and in the course 50°, we find it nearly corresponds to 212; half the sum of 208 and 212 is 210, which is the sought difference of longitude.

QUESTIONS

To exercise the learner.

Question I. A ship in the latitude of 32° N., sails due east till her difference of longitude is 384 miles; required the distance sailed.

Answer. 325.7 miles.

Quest. II. A ship from the latitude of 53° 36′ S., longitude 10° 18′ E., sails due west 236 miles; required her present longitude.

Ans. 3° 40′ E.

Quest. III. If two ships in the latitude of 44° 30′ N., distant 216 miles, should sail directly south until they were in the latitude of 32° 17′ N., what distance are they from each other?

Ans. By Theorem V., 256 miles.

Quest. IV. A ship having run due east for three days, at the rate of 5 knots an hour, finds she has altered her longitude 8° 16′; what parallel of latitude did sh sail in?

Ans. 43° 28′ N. or S.

Digitized by Google

MIDDLE LATITUDE SAILING.

In sailing north or south (or on a meridian) the difference of longitude is nothing, and the difference of latitude is equal to the distance sailed; but in sailing east or west (or on a parallel of latitude), the difference of latitude is nothing, and the difference of longitude may be calculated by the foregoing theorems of Parallel Sailing. In sailing on any other course, the ship changes both her latitude and longitude; in this case the difference of latitude, departure, and difference of longitude, may be calculated by a proper application of the principles of Plane Sailing to the sailing on a spherical surface; to do which, the surface of the globe may be supposed to be divided into an indefinite number of small surfaces, as square miles, furlongs, yards, &c., which, on account of their smallness, in comparison with the whole surface of the earth, may be esteemed as plane surfaces, and the difference of latitude and departure (or meridian distance) made in sailing over each of these surfaces, may be calculated by the common rules of Plane Sailing; and by summing up all the differences of latitude and departures made on these different planes, we shall obtain the whole difference of latitude and departure nearly.* Now, by Case I. of Plane Sailing, the distance described on any one of these small surfaces is to the corresponding difference of latitude as radius is to the cosine of the course; and as the course is the same on all these surfaces, it follows that the sum of all the distances described thereon, is to the sum of the corresponding differences of latitude as radius is to the cosine of the course; that is, the whole distance sailed on the globe, is to the corresponding difference of latitude as radius is to the cosine of the course. In a similar manner it appears, that the distance described on the globe is to the sum of all the corresponding departures (or meridian distances) described on these different surfaces, as radius is to the sine of the course; so that the canons for calculating the whole difference of latitude and departure from the course and distance are the same, whether the earth be esteemed as an extended plane or a spherical surface; and the same is to be observed with respect to the other cases of Plane Sailing.

We shall, therefore, in all the calculations of sailing on the spherical surface of the earth, in which the course, distance, difference of latitude and departure, occur, make use of the canons already taught in Plane Sailing, and shall construct the schemes exactly in the same manner. The only additional calculation in sailing on a spherical surface, consists in determining the longitude from the departure; for in sailing on a plane, the departure and longitude are the same; but in sailing on a spherical surface, *the whole departure (as was observed above) is equal to the sum of all the meridian distances made in sailing over the indefinite number of small surfaces, into which we have supposed the spherical surface to be divided, and the whole difference of longitude corresponding is equal to the sum of all the differences of longitude, deduced from each of these small meridian distances by Theorem* IV. *of Parallel Sailing.*† Several methods have been proposed for abridging the calculation of the difference of longitude from the departure, the most noted of which are those known by the names of *Middle Latitude Sailing* and *Mercator's Sailing;* the latter (which will be hereafter explained) is perfectly accurate;‡ the former is only an approximation, but it is very much used in calculating

* The error arising from this supposition will be decreased by increasing the number of the planes, so that, by increasing the number indefinitely, the error may be made less than any assignable quantity.

† Using (in estimating the difference of longitude corresponding to each of these small meridian distances) the latitude corresponding to the middle point of the surface on which these small meridian distances are respectively made.

‡ This is true in theory, and would be so in practice, if the meridional difference of latitude in Table III. were given to a sufficient number of decimals; but being only given to the nearest mile or minute, the error arising from this cause, when the difference of latitude is small, is greater than the error in Middle Latitude Sailing; in consequence of this, the method by middle latitude is almost exclusively used in the common operations on shipboard.

Digitized by Google

short runs and days' works; but in calculating large distances across distant parallels, it is liable to error. The principle on which the calculations of Middle Latitude Sailing are founded, is this:—Instead of calculating the difference of longitude corresponding to the departure made on each of the small surfaces, into which we have supposed the sphere to be divided, and adding them together, the whole departure (or sum of the meridian distances) is calculated, and the longitude deduced therefrom by the rules of Parallel Sailing, using for the latitude the arithmetical mean between the latitude sailed from and that arrived at. On this supposition, we have the two first of the following theorems for calculating the departure from the difference of longitude, or the difference of longitude from the departure, which are the same as Theorems III. and IV. of Parallel Sailing, except in writing departure for distance, and middle latitude for latitude: the other theorems are easily obtained by combining the two first with the common theorems of Plane Sailing; *observing that the middle latitude is half the sum of the two latitudes, if they are of the same name, or half their difference if of contrary names.* This method may be rendered perfectly accurate by applying to the middle latitude a correction taken from the table following Case VII. of this article We shall, however, in the following examples, make the calculations without applying this correction, because, in most cases in practice, it is of but little importance.

THEOREM I.

As radius is to the cosine of the middle latitude, so is the difference of longitude to the departure.

THEOREM II.

As the cosine of the middle latitude is to the radius, so is the departure to the difference of longitude.

Now, by Case I. of Plane Sailing, the radius is to the sine of the course, as the distance sailed is to the departure, and, if we combine this analogy with Theorem II., we shall have

THEOREM III.

As the cosine of the middle latitude is to the sine of the course, so is the distance sailed to the difference of longitude.

By Case II. of Plane Sailing, we have this analogy; As radius is to the tangent of the course, so is the difference of latitude to the departure; by combining this with Theorem II., we have

THEOREM IV.

As the cosine of the middle latitude is to the tangent of the course, so is the difference of latitude to the difference of longitude.

Whence we easily deduce the following,

THEOREM V.

As the difference of latitude is to the difference of longitude, so is the cosine of the middle latitude to the tangent of the course.

By means of the preceding theorems, we have formed the following table, which contains all the rules necessary for solving the various cases of Middle Latitude Sailing.

Digitized by Google

MIDDLE LATITUDE SAILING

Case.	Given.	Sought.	Solutions.
1	Both latitudes and longitude.	Departure. Course. Distance.	Radius : diff. of long. :: cosine middle lat. : departure. Difference of lat. : radius :: departure : tangent course. Diff. lat. : diff. long. :: cosine middle lat. : tangent course. Radius : difference of latitude :: secant course : distance Sine course : departure :: radius : distance.
2	Both latitudes and departure.	Course. Distance. Diff. of long.	Difference of lat. : radius :: departure : tangent course Sine course : departure :: radius : distance. Cosine middle lat. : departure :: radius : diff of long.
3	One latitude, course, and distance.	Diff. of latitude. Departure. Diff. of long.	Radius : distance :: cosine course : difference of latitude. Hence the other latitude and middle latitude are found. Radius : distance :: sine course : departure. Cosine middle lat. : departure :: radius : diff. of long. Cosine middle lat. : sine course :: distance : diff. of long.
4	Both latitudes and course.	Departure. Distance. Diff. of long.	Radius : diff. of lat. :: tangent course : departure. Cosine course : diff. of latitude :: radius : distance. Cosine middle lat. : departure :: radius : diff. of long. Cosine middle lat. : tangent course :: diff. lat. : diff. long.
5	Both latitudes and distance.	Course. Departure. Diff. of long.	Distance : radius :: diff. of latitude : cosine course. Radius : distance :: sine course : departure. Cosine middle lat. : departure :: radius : diff. of long.
6	One latitude, course, and departure.	Diff. of latitude. Distance. Diff. of long.	Radius : departure :: cotangent course : diff. of latitude. Hence the other latitude and middle latitude are known. Sine course : departure :: radius : distance. Cosine middle lat. : departure :: radius : diff. of long.
7	One latitude, distance, and departure.	Course. Diff. of latitude. Diff. of long.	Distance : radius :: departure : sine course. Radius : distance :: cosine course : difference of latitude. Hence we obtain the other latitude and middle latitude. Cosine middle lat. : departure :: radius : diff. of long.

We shall now proceed to illustrate these rules, by working an example in every case.

CASE I.

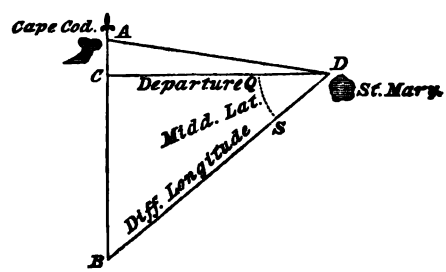
The latitudes and longitudes of two places given, to find their bearing and distance.

Required the bearing and distance between Cape Cod light-house, in the latitude of 42° 3′ N., longitude 70° 4′ W., and the island of St. Mary (one of the Western Islands), in the latitude of 36° 59′ N., and longitude 25° 10′ W.

Cape Cod's latitude..	42° 3′ N.		42° 3′	Longitude...	70° 4′ W.
St. Mary's latitude...	36 59 N.		36 59	Longitude...	25 10 W.
Difference of latitude	5 4	Sum......	79 2		44 54
	60	Middle lat.	39 31*		60
In miles	304			Diff. of long.	2694 miles

BY PROJECTION.

Draw the east and west line DC; with the chord of 60° describe the arc QS about the centre D, to cut DC in Q; upon this arc, set off, from Q to S, the middle latitude 39° 31′; through D and S draw the line DB, which make equal to the difference of longitude 2694 miles; from B let fall upon DC the perpendicular BC; continue this towards A, making AC equal to the difference of latitude 304 miles;† join AD, and it is done. For by this method of construction, on the principles before explained, A will be the situation of Cape Cod, D the situation of St. Mary; CD will be the departure, which, being measured,



* The correction of this quantity, in the table at the end of Case VII., is 3′ additive, making 39° 34′, which can be used instead of 39° 31′, if great accuracy be required.

† If the place A be to the southward of D, the line AC should be set off upon the line CB, from C towards B.

Digitized by Google

will be found to be 2078 miles; the distance will be represented by AD, which, being measured, will be found to be 2102 miles, and the course from Cape Cod to St. Mary will be represented by the angle CAD equal to 81° 41′; therefore the course will be S. 81° 41′ E., or E. ¾ S., nearly.

Note. The course is put S. 81° 41′ E. because St. Mary, being in a less northern latitude than Cape Cod, is to the southward of it; it is also to the eastward of Cape Cod, because it is in a less western longitude.

BY LOGARITHMS.

To find the departure (by Theorem I.)

As radius 90°	10.00000
Is to difference of long. 2694	3.43040
So is cosine middle lat. 39° 31′	9.88730
To the departure 2078	3.31770

To find the distance.

As radius 90°	10.00000
Is to the difference of lat. 304	2.48287
So is secant of course 81° 41′	10.83970
To the distance 2102	3.32257

Note. The logarithm of the departure above found, 3.31770, is rather greater than the logarithm of 2078=3.31765; but in finding the course by the departure, I have used the quantity found at the first operation, and shall do the same in all future calculations.

To find the course.

As difference of latitude 304	2.48287
Is to radius 45°	10.00000
So is the departure 2078	3.31770
To tangent of course 81° 41′	10.83483

Note. The course may be found without the departure, by Theorem V. Middle Latitude Sailing.

As the difference of latitude 304	2.48287
Is to the difference of long. 2694	3.43040
So is cosine middle lat. 39° 31′	9.88730
	13.31770
	2.48287
To tangent of course 81° 41′	10.83483

BY GUNTER.

Extend from the radius, or 90°, to 50° 29′, the complement of the middle latitude, on the line of sines; that extent will reach from the difference of longitude 2694, to the departure 2078, on the line of numbers.

2dly. Extend from the difference of latitude 304, to the departure 2078, on the line of numbers; that extent will reach from radius, or 45°, to the course 81° 41′, on the line of tangents.

3dly. Extend from the course 81° 41′, to the radius 90°, on the line of sines; that extent will reach from the departure 2078, to the distance 2102 miles, on the line of numbers.

BY INSPECTION.

Rule. Look for the middle latitude, as if it was a course in Plane Sailing, and the difference of longitude in the distance column, opposite to which, in the column of latitude, will stand the departure; having the difference of latitude and departure, the course and distance are found (as in Case VI. Plane Sailing) by seeking in Table II., with the difference of latitude and departure, until they are found to agree in their respective columns; opposite to them will be found the distance in its column, and the course will be found at the top of that table, if the departure be less than the difference of latitude, otherwise at the bottom.

Thus, with one tenth of the difference of longitude 269.4 or 269, I enter Table II., and opposite to it, in the distance column of the tables of 39° and 40°, I find 209.1, and 206.1 in the latitude column; now, the middle latitude being nearly 39½°, I take the mean of these, 207.6, for the departure, which being multiplied by 10, gives the whole departure 2076. Again, I enter Table I. with one tenth of the departure 207.6, and one tenth of the difference of latitude 30.4, and find that they agree nearly to a course of 7¼ points, and a distance of 210, which, multiplied by 10, gives the sought distance, 2100 miles, nearly.

Digitized by Google

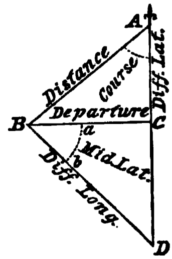
CASE II.

Both latitudes and departure from the meridian given, to find the course, distance, and difference of longitude.

A ship in the latitude of 49° 57′ N., and longitude of 15° 16′ W., sails south-westerly till her departure is 194 miles, and latitude in 47° 18′ N. Required the course, distance, and longitude in.

Latitude left...........	49° 57′ N.
Latitude in............	47 18 N.
Difference of latitude...	2 39 = 159 miles.
Sum of latitudes.	97 15
Middle latitude	48 38*

BY PROJECTION.



Draw the meridian ACD, on which take AC equal to the difference of latitude 159 miles; draw CB perpendicular to AC, and make it equal to the departure 194 miles; about B, as a centre, describe an arc ab, on which set off the middle latitude 48° 38′; through B and b draw the line BD, meeting ACD in D; join AB, and it is done; for AB will be the distance sailed, which, being measured, will be found equal to 250.8 miles; BD will be the difference of longitude, equal to 293.5 miles; and the angle CAB will represent the course from the meridian, 50° 40′.

BY LOGARITHMS.

To find the course.

As the difference of latitude 159	2.20140
Is to radius 45°	10.00000
So is the departure 194	2.28780
To tangent course 50° 40′	10.08640

To find the distance.

As sine course 50° 40′.........	9.88844
Is to the departure 194........	2.28780
So is radius 90°..............	10.00000
To the distance 250.8.........	2.39936

To find the difference of longitude.

As cosine middle lat. 48° 38′...	9.82012
Is to the departure 194........	2.28780
So is radius 90°..............	10.00000
To difference of long. 293.5....	2.46768

Longitude sailed from	15° 16′ W.
Difference of long. 294 miles.	4 54 W.
Longitude in	20 10 W

BY GUNTER.

1st. The extent from the difference of latitude 159, to the departure 194, on the line of numbers, will reach from radius, or 45°, to the course 50° 40′, on the line of tangents.

2dly. The extent from 50° 40′ to radius, or 90°, on the line of sines, will reach from the departure 194, to the distance 251, on the line of numbers.

3dly. The extent from the complement of middle latitude 41° 22′, to radius, or 90°, on the line of sines, will reach from the departure 194, to the difference of longitude 294, on the line of numbers.

BY INSPECTION.

Rule. With the difference of latitude and departure, find the course and distance (as in Case VI. of Plane Sailing), by seeking in Table II. until the difference of latitude and departure are found to correspond, against which, in the distance column, will be the distance; and if the departure be less than the difference of latitude, the course will be found at the top of that table, otherwise at the bottom.

Then take the middle latitude as a course, and find the departure in the latitude column; the number corresponding in the distance column will be the difference of longitude.

In the present example, with the difference of latitude 159, and the departure 194, we find that the nearest numbers to these are 158.0 and 195.1, standing together

* The correction of this latitude in the table at the end of Case VII. is about 1′, making the corrected middle latitude 48° 39′

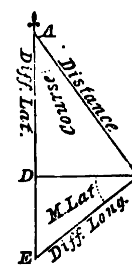
over 51°, against the distance 251; whence the course by inspection is S. 51° W., and the distance 251. Then, taking as a course 49° (which is the nearest to the middle latitude 48° 38′), seek for the departure 194 in the latitude column; the nearest number is 194.2; opposite to this, in the distance column, is 296, for the difference of longitude; this value differs a little from that found by logarithms, owing to the miles of middle latitude neglected; for if we were also to find the difference of longitude for the middle latitude 48°, and proportion for the minutes, the result would come out nearly the same as by logarithms.

CASE III.

One latitude, course, and distance given, to find the difference of latitude and difference of longitude.

A ship in the latitude of 42° 30′ N., and longitude 58° 51′ W., sails S. E. by S 300 miles. Required the latitude and longitude in.

BY PROJECTION.



Draw the meridian ADE (as in Case I. Plane Sailing); upon A, as a centre, describe an arc with the chord of 60°, and upon it set off, from where it cuts AD, the course S. E. by S., or 3 points; through that point of the arc, and the point A, draw the line AC, which make equal to the distance 300 miles; from C let fall upon AD the perpendicular CD; then will CD be the departure 166.7 miles, and AD the difference of latitude 249.4 miles. Hence we obtain the latitude arrived at, and the middle latitude; draw the line CE, making an angle with DC of 40° 26′ equal to the middle latitude; and the distance CE will be the difference of longitude 219 miles; hence the longitude is easily obtained.

BY LOGARITHMS.

To find the difference of latitude.

As radius 8 points	10.00000
Is to the distance 300	2.47712
So is cosine course 3 points	9.91985
To the difference of lat. 249.4	2.39697

Latitude left	42°	30′	N.
Difference of latitude	4	09	S.
Latitude in	38	21	N.
Sum of latitudes	80	51	
Middle latitude	40	26*	

Longitude left	58°	51′	W.
Difference of longitude 219	3	39	E.
Longitude in	55	12	W.

To find the departure.

As radius 8 points	10.00000
Is to the distance 300	2.47712
So is sine course 3 points	9.74474
To the departure 166.7	2.22186

To find the difference of longitude with the departure.

As cosine middle lat. 40° 26′	9.88148
Is to the departure 166.7 †	2.22186
So is radius 90°	10.00000
To difference of longitude 219	2.34038

Without the departure.

As cosine mid. lat. 40° 26′ Ar. Co.	0.11852
Is to sine course 3 points	9.74474
So is distance 300 miles	2.47712
To difference of longitude 219	2.34038

BY GUNTER.

1st. The extent from radius 8 points, to the complement of the course 5 points, on the line marked SR, will reach from the distance 300, to the difference of latitude 249, on the line of numbers.

2dly. The extent from radius 8 points, to the course 3 points, on the line SR, will reach from the distance 300, to the departure 167, on the line of numbers.

3dly. The extent from the complement of middle latitude 49° 34′, to radius 90°, on the line of sines, will reach from the departure 167, to the difference of longitude 219, on the line of numbers.

* The correction of this latitude in the table at the end of Case VII. is 2′, making the corrected middle latitude 40° 28′.

† The logarithm of the departure was found by the preceding canon to be 2.22186, differing a little from the logarithm of 166.7.

Digitized by Google

BY INSPECTION

Rule. With the course and distance, find the difference of latit de and departure (as in Case I. of Plane Sailing), by finding the given course at the top or bottom of the tables, either among the points or degrees; in that page, and opposite to the distance taken in its column, will stand the difference of latitude and departure in their columns. Then take the middle latitude as a course, and find the departure in the latitude column; against it, in the distance column, will stand the difference of longitude.

Thus, under the course three points, or S. E. by S., and against the distance 300, stand the difference of latitude 249.4, and the departure 166.7. With the middle latitude 40° 26′, or 40°, as a course, and the departure 166.7, found in the latitude column, we find, in the distance column, the difference of longitude 218.

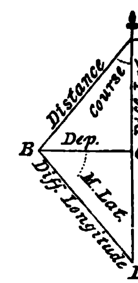
CASE IV.

Both latitudes and course given, to find the departure, distance, and difference of longitude.

Suppose a ship sailing from a place in the latitude of 49° 57′ N., and longitude of 30° W., makes a course good of S. 39° W., and then, by observation, is in the latitude of 47° 44′ N.; required the distance run, and the longitude in.

Latitude from..................	49° 57′ N.
Latitude by observation	47 44 N.
	2 13
	60
Difference of latitude	133
Sum of latitudes...............	97° 41′
Middle latitude	48 51 *

BY PROJECTION.



Draw the meridian ACD, on which set off AC equal to the difference of latitude 133 miles; draw CB perpendicular to AC; draw the line AB, making an angle equal to the course 39°, with AC, and meeting BC in B; through B draw BD, making an angle equal to the middle latitude 48° 51′, with the line BC, and it is done; for AB will be the distance 171.1 miles, BC the departure 107.7 miles, and BD the difference of longitude 163.7 miles.

BY LOGARITHMS.

To find the departure.

As radius 45°................	10.00000
Is to the difference of lat. 133..	2.12385
So is tangent of course 39° ...	9.90837
To the departure 107.7........	2.03222

To find the distance.

As cosine of the course 39°....	9.89050
Is to the difference of lat. 133..	2.12385
So is radius 90°..............	10.00000
To the distance 171.1.........	2.23335

To find the longitude in.

Longitude sailed from	30° 00′ W.
Difference of longitude 164..	2 44 W.
Longitude in	32 44 W.

To find the difference of longitude by the departure.

As cosine middle lat. 48° 51′...	9.81825
Is to the departure 107.7	2.03222
So is radius 90°..............	10.00000
To the difference of long. 163.7	2.21397

The difference of longitude may be found without the departure by Theorem IV. Middle Latitude Sailing; thus,

As cosine middle lat. 48° 51′. .	9.81825
Is to tangent of course 39°.....	9.90837
So is the difference of lat. 133..	2.12385
	12.03222
	9.81825
To the difference of long. 163.7	2.21397

BY GUNTER.

1st. The extent from radius 45°, to the course 39°, on the line of tangents, will reach from the difference of latitude 133, to the departure 107.7, on the line of numbers.

* The correction of this latitude in the table at the end of Case VII. is 1, making the corrected middle latitude 48° 52′

Digitized by Google

2dly. The extent from the complement of the course 51°, to the radius 90°, on the line of sines, will reach from the difference of latitude 133, to the distance 171.1, on the line of numbers.

3dly. The extent from the complement of the middle latitude 41° 09′, to radius 90° on the line of sines, will reach from the departure 107.7, to the difference of longitude 163.7, on the line of numbers.

BY INSPECTION.

Find the course among the points or degrees (in Table I. or II., as in Case II. Plane Sailing), and the difference of latitude in its column, against which will stand the distance and departure in their columns; then take the middle latitude as a course, and find the departure in the latitude column, against which, in the distance column, will stand the difference of longitude.

Thus, with the course 39°, and the difference of latitude 133, I enter Table II., the nearest number in the table is 132.9, which corresponds to the distance 171, and to the departure 107.6 miles.

Then with the middle latitude 48° 51′, or 49°, as a course, I enter Table II., and seek for the departure 107.6, in the latitude column, which corresponds to the distance 164, or the difference of longitude.

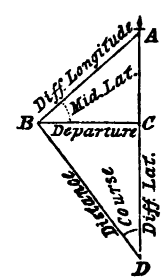
CASE V.

Both latitudes and distance given, to find the course, departure, and difference of longitude.

Suppose a ship sails 300 miles north-westerly from a place in the latitude of 37° N., and the longitude of 32° 16′ W., until she is in the latitude of 41° N.; required her course and longitude in.

Latitude left........	37° 0′ N.	....	37° 0′ N.
Latitude in.........	41 0	....	41 0
	4 0	Sum............	78 0
	60	Middle latitude...	39 0*
Difference of latitude	240		

BY PROJECTION.



Draw the meridian ACD, on which set off DC equal to the difference of latitude 240 miles; draw the line CB perpendicular to DC; take the distance 300 in your compasses, and, with one foot in D, as a centre, sweep an arc cutting CB in P: join DB; make the angle CBA equal to the middle latitude 39°, and draw BA cutting DCA in A, and it is done; for BC is the departure 180 miles, BA the difference of longitude 231.6 miles, and the angle BDC represents the angle of the ship's course with the meridian, which is therefore N. 36° 52′ W.

BY LOGARITHMS.

To find the course.

As the distance 300...........	2.47712
Is to radius 90°	10.00000
So is difference of latitude 240.	2.38021
To cosine course 36° 52′	9.90309

To find the departure.

As radius 90°................	10.00000
Is to the distance 300.........	2.47712
So is sine course 36° 52′.......	9.77812
To the departure 180.0........	2.25524

To find the difference of longitude by the departure.

As cosine middle latitude 39°..	9.89050
Is to the departure 180.0	†2.25524
So is radius 90°......	10.00000
To difference of long. 231.6....	2.36474

To find the longitude in.

Longitude left	32° 16′ W.
Difference of longitude	3 52 W.
Longitude in..............	36 8 W

* The correction of this latitude in the table at the end of Case VII. is 2′, making the corrected middle latitude 39° 2′.

† This logarithm, by the preceding operation, was found equal to 2.25524, differing a little from the logarithm of 180.0.

Digitized by Google

BY GUNTER

1st. The extent from the distance 300, to the difference of latitude 240, on the line of numbers, will reach from radius 90°, to the complement of the course, equal to 53° 8′ on the line of sines.

2dly. The extent from radius 90°, to the course 36° 52′, on the line of sines, will reach from the distance 300, to the departure 180, on the line of numbers.

3dly. The extent from the complement of the middle latitude 51°, to the radius 90° on the line of sines, will reach from the departure 180, to the difference of longitude 231.6, on the line of numbers.

BY INSPECTION.

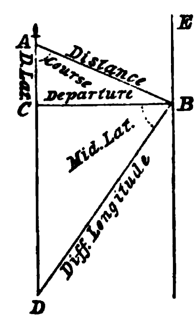
Find the course (as in Case IV. Plane Sailing) by seeking in Table II. till against the distance taken in its column is found the difference of latitude in one of the following columns; adjoining to it will stand the departure; which if less than the difference of latitude, the course is to be found at the top of the table, but if greater, at the bottom; then take the middle latitude as a course, and find the departure in the column of difference of latitude, against which, in the distance column, will stand the difference of longitude.

Thus the distance 300, and the difference of latitude 240, are found to correspond nearly to a course of 37°, and a departure of 180.5; then, taking the middle latitude 39° as a course, I seek the departure 180.5, in the latitude column, corresponding to which, in the distance column, is the difference of longitude 232.

CASE VI.

The latitude, course, and departure given, to find the difference of latitude, distance, and difference of longitude.

A ship in the latitude of 50° 10′ S., and longitude of 30° 00′ E., sails E. S. E. until her departure is 160 miles; required her distance sailed, and latitude and longitude in.



BY PROJECTION.

Draw the meridian ACD, and parallel thereto, at a distance equal to the departure 160 miles, draw the line EB; make the angle CAB equal to the course 6 points, and draw AB meeting EB in B; from B let fall upon AD the perpendicular BC; then is AC the difference of latitude 66.3 miles, and AB the distance sailed 173.2 miles; having thus obtained the middle latitude 50° 43′, make the angle CBD equal thereto, and draw BD meeting ACD in D; then will BD be the difference of longitude 252.7 miles.

BY LOGARITHMS.

To find the difference of latitude.

As radius 4 points............	10.00000
Is to the departure 160........	2.20412
So is cotangent course 6 points.	9.61722
To the difference of lat. 66.3...	1.82134

Latitude left...............	50° 10′ S.
Difference of latitude 66.....	1 06 S.
Latitude in................	51 16 S.
Sum of latitudes............	101 26
Middle latitude.............	50 43*

To find the distance.

As sine course 6 points.......	9.96562
Is to the departure 160........	2.20412
So is radius 8 points..........	10.00000
To the distance 173.2.........	2.23850

To find the difference of longitude.

As cosine middle latitude 50° 43′	9.80151
Is to the departure 160........	2.20412
So is radius 90°..............	10.00000
To the difference of long. 252.7	2.40261

Longitude left....................	30° 00′ E.
Difference of longitude 253.........	4 13 E.
Longitude in.....................	34 13 E.

* The correction of this latitude in the table at the end of Case VII. is insensible.

Digitized by Google

BY GUNTER.

1st. The extent from the course 6 points, to the radius 4 points, on the line marked TR, will reach from the departure 160, to the difference of latitude 66.3, on the line of numbers.

2dly. The extent from 6 points, to the radius, or 8 points, on the line marked SR, will reach from the departure 160, to the distance 173.2, on the line of numbers.

3dly. The extent from the complement of the middle latitude 39° 17′, to the radius 90°, on the sines, will reach from the departure 160, to the difference of longitude 252.7, on the line of numbers.

BY INSPECTION.

Find the course among the points or degrees, Table I. or Table II. (as in Case III. Plane Sailing), and the departure in its column, corresponding to which, in the columns of distance and difference of latitude, will be found the distance and difference of latitude respectively; then with the middle latitude as a course, seek the departure in the column of latitude, corresponding to which, in the distance column, will stand the difference of longitude.

Thus, I enter Table I., above E. S. E., or 6 points, and seek for the departure 160, the nearest to which is 159.8; the corresponding numbers give the distance 173, and the difference of latitude 66.2 miles.

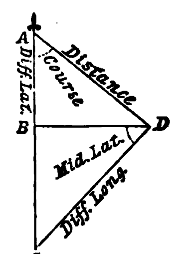
Enter Table II. with the middle latitude 50° 43′, or (51° nearly) as a course, and seek for the departure 160, in the latitude column, opposite to which, in the distance column, will be found the difference of longitude 254 miles, nearly.

CASE VII.

One latitude, distance sailed, and departure from the meridian given, to find the course, difference of latitude, and difference of longitude.

A ship in the latitude of 49° 30′ N., and longitude of 25° 0′ W., sails south-easterly 215 miles, until her departure from the meridian be 167 miles; required the course steered, and the latitude and longitude the ship is in.

BY PROJECTION.



Draw the line BD equal to the departure 167 miles, and perpendicular thereto draw the meridian line ABC; take an extent equal to the distance 215, in your compasses, and with one foot in D, as a centre, describe an arc cutting AB in A; join AD; then will AB be the difference of latitude 135.4 miles, and BAD the course, S. 50° 58′ E. Hence we have the latitude in, and middle latitude; make the angle BDC equal to the middle latitude, and draw DC cutting ABC in C; then DC will be the difference of longitude 251.5 miles.

BY LOGARITHMS.

To find the course.

As the distance 215	2.33244
Is to the radius 90°	10.00000
So is the departure 167	2.22272
To sine course 50° 58′	9.89028

To find the difference of latitude.

As radius	10.00000
Is to the distance 215	2.33244
So is cosine course 50° 58′	9.79918
To the difference of lat. 135.4 ..	2.13162

To find the difference of longitude.

As cosine middle lat. 48° 23′ ...	9.82226
Is to the departure 167	2.22272
So is radius	10.00000
To the difference of long. 251.5	2.40046

Latitude left	49° 30′ N
Difference of latitude 135 ...	2 15 S
Latitude in	47 15 N
Sum of the latitudes	96 45
Middle latitude	48 23*

Longitude left	25° 00′ W
Difference of longitude 252 ..	4 12 E.
Longitude in	20 48 W

* The correction of this latitude in the table is 1′, making the corrected middle latitude 48° 24′

Digitized by Google

BY GUNTER.

1st. The extent from the distance 215, to the departure 167, on the line of numbers, will reach from the radius 90°, to the course 50° 58′ on the line of sines.

2dly. The extent from radius 90°, to the complement of the course 39° 02′ on the line of sines, will reach from the distance 215, to the difference of latitude 135.4, on the line of numbers.

3dly. The extent from the complement of the middle latitude 41° 37′, to the radius 90°, on the line of sines, will reach from the departure 167, to the difference of longitude 251.5, on the line of numbers.

BY INSPECTION.

As in Case V. Plane Sailing, find the course by seeking in Table II. till against the distance, in its column, is found the given departure in one of the following columns, adjoining to which, in the other column, will be the difference of latitude, which if greater than the departure, the course will be at the top, but if less the course will be found at the bottom. Then take the middle latitude as a course, and find the departure in the column of difference of latitude, against which, in the distance column, will be found the difference of longitude.

Thus the distance 215, and the departure 167, are found nearly to correspond to a course of 51 degrees, and a difference of latitude of 135.3; then with the middle latitude 48°, as a course, I enter the table, and seek for the departure 167, in the latitude column; the distance corresponding 250 is the difference of longitude nearly.

In all the preceding examples, we have used the middle latitude, without any correction, in computing the difference of longitude; but when absolute accuracy is required, this latitude must be corrected. We have given in the following table the value of this correction in the most common cases. It requires no particular explanation: one example will serve to show its use. Suppose, therefore, the two latitudes to be 40° and 60°. Here the middle latitude is 50°, and the difference of latitude 20°; the tabular correction corresponding to these numbers is 57′; adding this to 50°, we get the corrected middle latitude 50° 57′, which is to be used instead of 50°, when great accuracy is required. We have inserted in the notes at the bottom of the pages, in the preceding examples, the values of this correction, but have not introduced it into the calculations, because it is generally unnecessary on account of its smallness.

TABLE.

This Table contains the correction, in minutes, to be added to the Middle Latitude to obtain the corrected Middle Latitude.

Mid. Lat.	Difference of Latitude.															Mid. Lat.
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	12°	14°	16°	18°	20°	
°	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	°
15	0	1	2	3	5	7	9	12	15	18	26	36	47	59	72	15
18	0	1	1	3	4	6	8	10	13	16	23	32	41	52	64	18
21	0	1	1	2	4	5	7	9	12	15	21	29	37	47	58	21
24	0	1	1	2	3	5	7	9	11	14	20	27	35	44	54	24
30	0	1	1	2	3	5	6	8	10	13	18	25	32	41	50	30
35	0	1	1	2	3	4	6	8	10	12	18	24	32	40	49	35
40	0	1	1	2	3	5	6	8	10	13	18	25	32	41	50	40
45	0	1	1	2	3	5	6	8	11	13	19	26	34	43	53	45
50	0	1	1	2	4	5	7	9	11	14	20	28	36	46	57	50
55	0	1	1	3	4	6	8	10	13	16	22	31	40	51	63	55
58	0	1	2	3	4	6	8	11	14	17	24	33	43	55	68	58
60	0	1	2	3	4	6	9	11	14	18	26	35	46	58	72	60
62	0	1	2	3	5	7	9	12	15	19	27	37	49	62	77	62
64	0	1	2	3	5	7	10	13	16	20	29	40	52	67	83	64
66	0	1	2	4	5	8	11	14	18	22	32	43	57	72	90	66
68	0	1	2	4	6	8	12	15	19	24	34	47	62	79	99	68
70	0	1	2	4	6	9	13	16	21	26	38	52	68	88	110	70
72	0	1	3	5	7	10	14	18	23	29	42	58	76	98	124	72

This Table is to be entered at the top with the *difference* of the two latitudes, and at the side with the *middle latitude*; under the former, and opposite to the latter, is the correction, in minutes, to be added to the middle latitude, to obtain the corrected middle latitude.

Digitized by Google

QUESTIONS FOR EXERCISE.

Question I. Required the bearing and distance between two places, one in the latitude of 37° 55′ N., and longitude of 54° 23′ W.; the other in the latitude of 32° 38′ N., and longitude of 17° 5′ W.

Answer. S. 80° 9′ E., and N. 80° 9′ W., distance 1854 miles.

Quest. II. Required the direct course and distance, from a place in the latitude of 36° 55′ S., and longitude of 20° 0′ E., to another place in the latitude of 32° 38′ S., and longitude of 8° 54′ W.

Ans. N. 79° 46′ W., distance 1447 miles.

Quest. III. A ship from the latitude of 37° 30′ S., and longitude of 60° E., sails N. 79° 56′ W. 202 miles; required the latitude and longitude in.

Ans. Latitude 36° 55′ S., longitude 55° 50′ E.

Quest. IV. A ship from the latitude of 34° 35′ N., and longitude of 45° 16′ W., sails S. 83° 36′ E., 101 miles; required her latitude and longitude.

Ans. Latitude 34° 24′ N., longitude 43° 14′ W.

Quest. V. A ship in the latitude of 49° 57′ N., and longitude of 15° 16′ W., sails south-westerly till her departure is 789 miles, and latitude in 39° 20′ N.; required the course, distance, and longitude in.

Ans. Course S. 51° 05′ W., distance 1014 miles, longitude in 33° 45′ W.

Quest. VI. A ship in the latitude of 42° 30′ N., and longitude 58° 51′ W., sails S. E. by S. 591 miles; required the latitude and longitude in.

Ans. Latitude 34° 19′ N., longitude 51° 52′ W.

Quest. VII. Suppose a ship sailing from a place in the latitude of 49° 57′ N., and longitude of 30° W., makes a course good of S. 39° W., and then, by observation, is in the latitude of 45° 31′ N.; required the distance run, and longitude in.

Ans. Distance 342.3, longitude 35° 20′ W.

Quest. VIII. A ship in the latitude of 50° 10′ S., and longitude of 30° 00′ E., sails E. S. E. until her departure is 957 miles; required her distance sailed, and latitude and longitude in.

Ans. Distance 1036 miles, latitude 56° 46′ S., longitude 56° 48′ E.

Quest. IX. A ship in the latitude of 49° 30′ N., and longitude of 25° 00′ W., sails south-easterly 645 miles, until her departure from the meridian be 500 miles; required the course steered, and the latitude and longitude the ship is in.

Ans. Course S. 50° 49′ E., latitude 42° 42′ N. longitude 12° 59′ W

Digitized by Google

MERCATOR'S SAILING.

The calculations by Middle Latitude Sailing are sufficiently exact for a short run, or a day's work, and are to be preferred in all cases where the difference of latitude is small in comparison with the difference of longitude; but this method is liable to great errors in calculating the situations of places differing greatly in latitude and longitude, particularly in high latitudes. To remedy this inconvenience, a chart was invented and published in the year 1566, by GERARD MERCATOR, a Flemish geographer, in which all the meridians are parallel to each other, but proportionally lengthened so as to conform to the spherical figure of the earth. The principles on which this chart is constructed were first explained in the year 1599, by Edward Wright, an Englishman, and are as follows:—

By Theorem II. of Parallel Sailing, the distance of two meridians corresponding to a degree or mile of longitude, in any latitude, is to the length of a corresponding degree or mile of the meridian, as the cosine of the latitude is to the radius, that is (by *Art.* 56, Geometry), as radius is to the secant of the latitude. Hence, if the meridians are supposed to be parallel to each other, or the distance of the meridians to remain the same in every latitude, the degree or mile of latitude must be increased in proportion to the secant of the latitude. Therefore, if the radius be supposed to be equal to one mile, the length of the first mile of latitude from the equator will be represented by the secant of 1′; the second mile, by the secant of 2′; the third mile, by the secant of 3′, &c. Therefore the length of the expanded arc of the meridian may be found by a continual addition of secants, to every degree and minute of the quadrant, as in Table III., by means of which the chart (called Mercator's Chart) may be constructed, and all the cases of Mercator's Sailing may be projected and calculated.*

In using this table, the degrees are to be found at the top or the bottom, and the miles at the side; in the angle of meeting will be the length of the corresponding expanded arc, usually called the *meridional parts.* If you wish to find the arc of the expanded meridian intercepted between any two parallels, or, as it is usually called, the *meridional difference of latitude,* you must, *when both places are on the same side of the equator, subtract the meridional parts of the least latitude from the meridional parts of the greatest; the remainder will be the meridional difference of latitude: but if they are on different sides of the equator, the sum of the meridional parts of both latitudes will be the meridional difference of latitude required.*

EXAMPLE I.

Required the meridional parts corresponding to the latitude of 42° 34′.

Look in the bottom or top of the table for 42°, and in the right or left hand column, marked (M), for 34′; under the former and opposite the latter stand 2828, the meridional parts corresponding to 42° 34′.

EXAMPLE II.

Required the meridional difference of latitude between Cape Cod, in the latitude of 42° 03′ N., and the island of St. Mary, in the latitude of 36° 59′ N.

Cape Cod's latitude	42° 03′ N.	Meridional parts	2786
St. Mary's latitude	36° 59′ N.	Meridional parts	2391
Meridional difference of latitude			395

---

* The manner of constructing this chart will be particularly explained hereafter. It may be observed, that the smaller the subdivisions of the arc of the meridian are, the greater will be the accuracy of the calculated length of the expanded arc of the meridian. To be perfectly accurate, the arc ought to be subdivided into the smallest quantities possible. Attention was paid to this circumstance in calculating the above-mentioned table.

Digitized by Google

EXAMPLE III.

Required the meridional difference of latitude between a place in the latitude of 35° 12′ N., and the Cape of Good Hope, in the latitude of 34° 22′ S.

Latitude	35° 12′ N.	Meridional parts	2259
Cape of Good Hope's lat.	34° 22′ S.	Meridional parts	2198
Sum is meridional difference of latitude.............			4457

From these principles it follows, that in sailing upon any course, *the true or proper difference of latitude is to the departure as the meridional difference of latitude is to the difference of longitude.* Hence if MI (in the figure of Case I. following) be the proper difference of latitude, IO the departure, MO the distance, the angle IMO the course, and we take MT equal to the meridional difference of latitude, and draw TH parallel to IO to cut MO continued in H, the line TH will represent the difference of longitude for (by *Art.* 53, Geometry) MI : IO :: MT : TH. Now, in the triangle MTH, by making MT radius, we have MT : radius :: TH : tangent TMH; that is, *the meridional difference of latitude is to radius, as the difference of longitude is to the tangent of the course.* By making MH or TH radius, we shall have other analogies, which, being combined with those in Plane Sailing, furnish the solutions of the various cases of Mercator's Sailing contained in the following table.

MERCATOR'S SAILING.

Case.	Given.	Sought.	Solutions.
1	Both latitudes and longitudes.	Course Distance. Departure.	Having both lats. the mer. diff. lat. is found by Table III. Mer. diff. of lat. : radius :: diff. of long. : tangent course. { Radius : proper diff. of latitude :: secant course : distance. { Cosine course : prop. diff. of latitude :: radius : distance. { Radius : proper diff. of lat. :: tangent course : departure. { Mer. diff. of lat. : diff. of long. :: prop. diff. of lat. : depart.
2	Both latitudes and departure.	Course. Distance. Diff. of long.	Merid. diff. of lat. being found by Table III., we have Proper diff. of lat. : radius :: departure : tangent course. { Radius : proper diff. of latitude :: secant course : distance. { Sine course : departure :: radius : distance. { Radius : merid. diff. of lat. :: tangent course : diff. of long. { Prop. diff. of lat. : departure :: mer. diff. of lat. : diff. long.
3	One latitude, course, and distance.	Departure. Diff. of latitude. Diff. of long	Radius : distance :: sine course : departure. Radius : dist. :: cosine course : prop. diff. of lat. Hence we have the other latitude and mer. diff. of lat. by Table III. Radius : merid. diff. of lat. :: tangent course : diff. of long.
4	Both latitudes and course.	Distance. Departure. Diff. of long.	Cosine course : proper diff. of latitude :: radius : distance. Radius : proper diff. of lat. :: tangent course : departure. Merid. diff. of lat. being found in Table III., we have Radius : merid. diff. of lat. :: tangent course : diff. of long.
5	Both latitudes and distance.	Course. Departure. Diff. of long.	Distance : radius :: proper diff. of latitude : cosine course. Radius : distance :: sine course : departure. Radius : merid. diff. of lat. :: tangent course : diff. of long.
6	One latitude, course, and departure.	Diff. of latitude. Distance. Diff. of long.	Radius : departure :: cotangent course : proper diff. of lat. Hence we have the other latitude and merid. diff. of lat. Sine course : departure :: radius : distance. { Radius : merid. diff. of lat. :: tangent course : diff. of long. { Prop. diff. of lat. : departure :: mer. diff. of lat. : diff. long.
7	One latitude, distance, and departure.	Course. Diff. of latitude. Diff. of long.	Distance : radius :: departure : sine course. Radius : distance :: cosine course : diff. of lat. Hence we obtain the other latitude and merid. difference of latitude. { Radius : merid. diff. of lat. :: tangent course : diff. of long. { Prop. diff. of lat. : departure :: mer. diff. of lat. : diff. long.

CASE I.

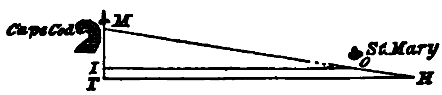
The latitudes and longitudes of two places given, to find the direct course and distance between them.

Required the bearing and distance from Cape Cod light-house, in the latitude of 42° 03′ N., and longitude 70° 04′ W., to the island of St. Mary one of the Western Islands, in the latitude of 36° 59′ N., and longitude of 25° 10′ W.

Digitized by Google

Cape Cod's latitude	42° 3′ N.	Meridional parts .. 2786	Longitude 70° 4′ W
St. Mary's latitude.	36 59 N.	Meridional parts .. 2391	25 10 W.
	5 4	Merid. diff. of lat. 395	44 54
	60		60
Difference of lat. ..	304 miles.	Difference of long.	2694 miles.

BY PROJECTION.



Draw the meridian MT equal to the meridional difference of latitude 395 miles; set off also upon it MI equal to the proper difference of latitude 304 miles; perpendicular to MT draw TH and IO; make TH equal to the difference of longitude 2694 miles draw MH cutting IO in O; then will the angle TMH be the course S. 81° 40′ E., and OM the distance 2098 miles.

BY LOGARITHMS.

To find the course.		To find the distance	
As the merid. diff. of latitude 395	2.59660	As radius 90°	10.00000
Is to radius 45°	10.00000	Is to the proper diff. of lat. 304.	2.48287
So is the difference of long. 2694	3.43040	So is secant of course 81° 40′ ..	10.83884
To tangent of course 81° 40′...	10.83380	To the distance 2098 miles	3.32171

BY GUNTER.

1st. Extend from the meridional difference of latitude 395, to the difference of longitude 2694, on the line of numbers; that extent will reach from the radius or 45°, to the course 81° 40′, on the line of tangents.

2dly. Extend from the complement of the course 8° 20′, to radius 90°, on the line of sines; that extent will reach from the proper difference of latitude 304, to the distance 2098, on the line of numbers.

BY INSPECTION.

With the meridional difference of latitude and difference of longitude used as difference of latitude and departure, find the course, by inspecting the tables until those numbers are found to correspond; with this course and the proper difference of latitude, find the corresponding distance.

Thus one tenth of the meridional difference of latitude and difference of longitude are found to agree nearly to a course of 7¼ points; this course and one tenth of the proper difference of latitude 30.4, is found to correspond to the distance 207; this multiplied by 10 gives the distance 2070, differing a little from the result by logarithms, owing to the neglect of a few minutes in the course.

CASE II.

Both latitudes and the departure given, to find the course, distance, and difference of longitude.

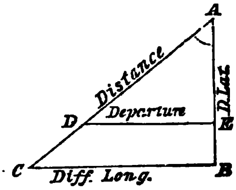
A ship in the latitude of 49° 57′ N., and longitude of 15° 16′ W., sails south-westerly until her departure is 197 miles, and then, by observation, is in the latitude of 47° 18′ N.; required her course, distance, and longitude in.

Latitude left.............	49° 57′ N.	Meridional parts	3470
Latitude in..............	47 18 N.	Meridional parts	3229
Difference of latitude	2 39 = 159 miles.	Merid. diff. of latitude	241

Digitized by Google

BY PROJECTION.

With the proper difference of latitude and departure, project as in Case VI. Plane Sailing, by drawing the meridian AEB, on which take AE equal to the proper difference of latitude 159 miles; erect ED perpendicular to AE, and make it equal to the departure 197 miles; join AD, and continue it towards C; make AB equal to the meridional difference of latitude 241 miles, and draw BC perpendicular to AB, to cut AC in C, and it is done. For AD will be the distance 253.2 miles, BC the difference of longitude 298.6 miles, and the angle BAC will be the course S. 51° 06′ W.



BY LOGARITHMS.

To find the course.

As the proper diff. of lat. 159 ..	2.20140
Is to radius 45°	10.00000
So is the departure 197	2.29447
To tangent course 51° 06′	10.09307

To find the difference of longitude.

As radius 45°	10.00000
Is to merid. diff. of latitude 241	2.38202
So is tangent course 51° 06′... *	10.09307
To difference of longitude 298.6	2.47509

To find the distance.

As radius	10.00000
Is to proper diff. of latitude 159	2.20140
So is secant course 51° 06′.....	10.20207
To the distance 253.2.........	2.40347

Longitude left	15° 16′ W.
Difference of longitude	4 59 W
Longitude in	20 15 W

The difference of longitude may also be found by saying, As proper difference of latitude : departure :: meridional difference of latitude : difference of longitude.

BY GUNTER.

1st. The extent from the difference of latitude 159, to the departure 197, on the line of numbers, will reach from radius 45°, to the course 51° 06′, on the line of tangents.

2dly. The extent from the course 51° 06′, to radius 90°, on the sines, will reach from the departure 197, to the distance 253.2, on the line of numbers.

3dly. The extent from the radius 45°, to the course 51° 06′, on the line of tangents, will reach from the meridional difference of latitude 241, to the difference of longitude 298.6, on the line of numbers.

BY INSPECTION.

Find the course by Plane Sailing, Case VI., by seeking in the tables with the proper difference of latitude and departure till they are found to agree in their respective columns, corresponding to which will be the distance in its column, and the course will be found at the top of that column if the departure is less than the proper difference of latitude, otherwise at the bottom; with the same course find the meridional difference of latitude in the latitude column, corresponding to which, in the departure column, will be the true difference of longitude.

Thus with the true difference of latitude and departure 159, and 197, I find the course 51°, and the distance 253; in the same table, opposite to half of the meridional difference of latitude 120.5, I find the departure 148.8, which, being multiplied by 2, gives the difference of longitude 298 miles, nearly.

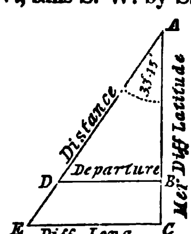
CASE III.

One latitude, course, and distance given, to find the difference of latitude and difference of longitude.

A ship in the latitude of 42° 30′ N., and longitude of 58° 51′ W., sails S. W. by S. 300 miles; required the latitude and longitude in.

BY PROJECTION.

Draw the meridian ABC and ADE, making an angle with it equal to the course 3 points; make AD equal to the distance sailed 300 miles, and from D let fall upon AB the perpendicular BD; then will BD be the departure, and AB the difference of latitude 249.4 miles. Hence we have both latitudes, and the meridional difference of latitude, to which make AC equal, and draw CE parallel to BD, meeting ADE in E; then will CE be the difference of longitude 218.5 miles.



Digitized by Google

* This logarithm, by the preceding operation, was found equal to 10.09307, differing a little from the log. tang. of 51° 06

BY LOGARITHMS.

To find the difference of latitude.	
As radius 8 points............	10.00000
Is to the distance 300.........	2.47712
So is cosine course 3 points....	9.91985
To proper diff. of latitude 249.4	2.39697

To find the difference of longitude	
As radius 4 points	10.00000
Is to the merid. diff. of lat. 327.	2.51455
So is tangent course 3 points...	9.82489
To difference of longitude 218.5	2.33944

Latitude left ..	42° 30′ N.	Meridional parts 2822	Longitude left ..	58° 51′ W.
Diff. of lat. 249	4 09 S.		Diff. of long. 219	3 39 W.
Latitude in....	38 21 N.	Meridional parts 2495	Longitude in ...	62 30 W.
		Mer. diff. of lat. 327		

BY GUNTER.

1st. The extent from radius 8 points, to the complement of the course 3 points, on the line marked SR, will reach from the distance 300, to the difference of latitude 249.4, on the line of numbers.

2dly. The extent from the radius 4 points, to the course 3 points, on the line marked TR, will reach from the meridional difference of latitude 327, to the difference of longitude 218.5, on the line of numbers.

BY INSPECTION.

As in Case I. Plane Sailing, find the course at the top or bottom of the tables, either among the points or degrees, and in that page, opposite the distance, will be found the difference of latitude and departure in their respective columns. Then, in the same table, find the meridional difference of latitude, in the latitude column; corresponding to which, in the departure column, will be the difference of longitude.

Thus, under the course S. W. by S. or 3 points, and opposite the distance 300 stands the difference of latitude 249.4. Then under the same course find half of the meridional difference of latitude in the latitude column, against which stands 109 nearly, in the departure column; which, multiplied by two, gives 218, the difference of longitude, nearly.

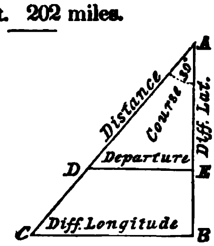
CASE IV.

Both latitudes and course given, to find the distance and difference of longitude.

A ship from the latitude of 49° 57′ N., and longitude of 30° W., sails S. 39° W., till she arrives in the latitude of 47° 44′ N.; required the distance run, and longitude in.

Latitude left ..	49° 57′ N.	Meridional parts	3470
Latitude in ...	47 44 N.	Meridional parts	3268
Diff. of latitude	2 13 = 133 miles.	Mer. diff. of lat.	202 miles.

BY PROJECTION.



Draw the meridian AEB, on which take AE equal to the proper difference of latitude 133 miles, and AB equal to the meridional difference of latitude 202 miles; make the angle BAC equal to the course 39°, and draw ED, BC, perpendicular to AB, cutting ADC in D and C; then will AD be the distance 171.1 miles, and BC the difference of longitude 163.6 miles.

BY LOGARITHMS.

To find the distance.	
As the cosine course 39°	9.89050
Is to the proper diff. of lat. 133.	2.12385
So is radius 90°..............	10.00000
To the distance 171.1.........	2.23335

To find the difference of longitude.	
As radius 45°................	10.00000
Is to merid. diff. of latitude 202.	2.30535
So is tangent course 39°.......	9.90837
To the difference of long. 163.6	2.21372

Longitude left................	30° 0′ W.
Difference of longitude........	2 44 W.
Longitude in.................	32 44 W

Digitized by Google

BY GUNTER.

1st. The extent from the complement of the course 51°, to the radius 90°, on the sines, will reach from the proper difference of latitude 133, to the distance 171.1, on the line of numbers.

2dly. The extent from radius 45°, to the course 39°, on the line of tangents, will reach from the meridional difference of latitude 202, to the difference of longitude 163.6, on the line of numbers.

BY INSPECTION.

As in Case II. Plane Sailing, find the course among the points or degrees, and the proper difference of latitude in its column, adjoining to which will be the distance and departure in their respective columns; then, in the same table, find the meridional difference of latitude in the latitude column, adjoining to which, in the departure column, will be the difference of longitude.

Thus, under the course 39°, and opposite the difference of latitude 133 (the nearest to which is 132.9), stand the distance 171, and the departure 107.6; in the same table, opposite the meridional difference of latitude 202, found in the latitude column, stands 163.6, in the departure column, which is the difference of longitude, as before.

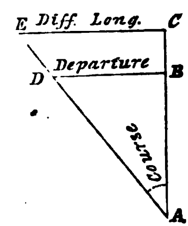
CASE V.

Both latitudes and distance given, to find the course and difference of longitude.

A ship from the latitude of 37° N., and longitude of 32° 16′ W., sails 300 miles north-westerly, until she is in the latitude of 41° N.; required the course steered, and longitude in.

Latitude left	37° N.	Meridional parts.	2393
Latitude in	41° N.	Meridional parts.	2702
Difference of lat.	4° = 240 miles.	Merid. diff. of lat.	309 miles.

BY PROJECTION.



Draw the meridian ABC; make AB equal to the proper difference of latitude 240, and AC equal to the meridional difference of latitude 309 miles; draw BD and CE perpendicular to ABC; with an extent equal to the distance 300 in your compasses, and one foot in A, as a centre, describe an arc cutting BD in D; draw AD, and continue it to cut CE in E, and it is done; for the angle BAD is equal to the course of 36° 52′, BD is the departure, and CE is the difference of longitude 231.7 miles.

BY LOGARITHMS.

To find the course.		To find the difference of longitude.	
As the distance 300...........	2.47712	As radius 45°................	10.00000
Is to radius 90°	10.00000	Is to the merid. diff. of lat. 309.	2.48996
So is proper diff. of latitude 240	2.38021	So is tangent course 36° 52′ ...	9.87501
To cosine course 36° 52′	9.90309	To the difference of long. 231.7	2.36497

Longitude left................	32° 16′ W.
Difference of longitude 232 =	3 52 W.
Longitude in.................	36 08 W

BY GUNTER.

1st. The extent from the distance 300, to the proper difference of latitude 240, on the line of numbers, will reach from the radius, or 90°, to 53° 8′, the complement of the course on the line of sines.

2dly. The extent from radius 45°, to the course 36° 52′, on the line of tangents, will reach from the meridional difference of latitude 309 to the difference of longitude 231.7, on the line of numbers.

Digitized by Google

BY INSPECTION.

As in Case IV. Plane Sailing, seek in the table till against the distance, taken in its column, is found the given difference of latitude in one of the following columns; adjoining to it will stand the departure, which if less than the difference of latitude, the course will be found at the top, otherwise at the bottom; in the same table find the meridional difference of latitude in the latitude column, adjoining to which in the departure column will stand the difference of longitude.

Thus the distance 300, and the difference of latitude 240, are found to correspond to a course of 37°, and a departure of 180.5; and in the latitude column, opposite half the meridional difference of latitude 154.5 (the nearest to which is 154.1), stands 116.2 in the departure column, which doubled gives the difference of longitude 232.4.

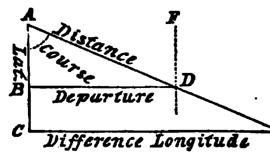
CASE VI.

One latitude, course, and departure, given, to find the distance, difference of latitude, and difference of longitude.

A ship from the latitude of 50° 10′ S., and longitude of 30° E., sails E. S. E. until her departure is 160 miles; required the distance sailed, and the latitude and longitude in.

BY PROJECTION.

Draw the meridian ABC, and at a distance from it equal to the departure 160 miles, draw the line FD parallel to ABC; make the angle BAD equal to the course 6 points; draw AD to cut FD in D; from D let fall upon AB the perpendicular DB; then will AD be the distance 173.2 miles, AB the difference of latitude 66.3 miles; hence we have both latitudes, and the meridional difference of latitude 104 miles; make the line AC equal thereto, and draw CE perpendicular to AC, meeting AD continued in E; then will CE be the difference of longitude 251.1 miles.



BY LOGARITHMS.

To find the distance.

As the sine course 6 points	9.96562
Is to the departure 160........	2.20412
So is radius 8 points..........	10.00000
To the distance 173.2.........	2.23850

To find the difference of latitude.

As radius 4 points............	10.00000
Is to the departure 160......	2.20412
So is cotangent course 6 points.	9.61722
To proper diff. of lat. 66.3 miles	1.82134

Latitude left ..	50° 10′ S.	Mer. parts 3490
Diff. of latitude	1 06 S.	
Latitude in...	51 16 S.	Mer. parts 3594
	Merid. difference of latitude	104

To find the difference of longitude.

As radius 4 points............	10.00000
Is to the merid. diff. of lat. 104.	2.01703
So is tangent course 6 points ..	10.38278
To diff. of long. 251 = 4° 11′ E.	2.39981
Longitude left ...... 30 00 E.	
Longitude in .... 34 11 E.	

BY GUNTER.

1st. The extent from the course 6 points, to radius 8 points, on the line marked S. R. will reach from the departure 160, to the distance 173.2, on the line of numbers.

2dly. The extent from radius 4 points, to the complement of the course 2 points, on the line marked T. R., will reach from the departure 160, to the difference of latitude 66.3, on the line of numbers.

3dly. The same extent (from the radius 4 points to the course 6 points on the line marked T. R.) will reach from the meridional difference of latitude 104, to the difference of longitude 251, on the line of numbers.

BY INSPECTION.

As in Case III. Plane Sailing, find the course either in Table I. or Table II., and the departure in its column, corresponding to which will stand the distance and difference of latitude in their respective columns; in the same table find the meridional difference

Digitized by Google

of latitude, in the latitude column, corresponding to which, in the departure column, will be found the difference of longitude.

Thus, over the course E. S. E. or 6 points, and against the departure 160, stands the distance 173 miles, and the difference of latitude 66.2 miles. Again, in the same table, find the meridional difference of latitude 104, in the latitude column, opposite to which, in the departure column, stands the difference of longitude 251.3 miles.

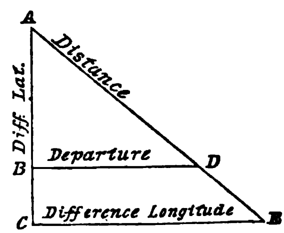
CASE VII.

One latitude, distance sailed, and departure given, to find the course, difference of latitude, and difference of longitude.

A ship in the latitude of 49° 30′ N., and the longitude of 25° W., sails south-easterly 215 miles, making 167 miles departure; required the course steered, and the latitude and longitude in.

BY PROJECTION.

Draw the meridian ABC, and on any point of it draw BD perpendicular thereto, and make it equal to the departure 167 miles; with an extent equal to the distance 215 miles in your compasses, and one foot on D, as a centre, describe an arc to cut AB in A; join AD; then will AB be the proper difference of latitude 135.4 miles, and the angle BAD will be the course 50° 58′; hence we have the other latitude, and the meridional difference of latitude, to which make AC equal, and draw CE parallel to BD, meeting AD produced in E; then will CE be the difference of longitude 250.4 miles.



BY LOGARITHMS.

To find the course.

As the distance 215	2.33244
Is to the radius 90°	10.00000
So is the departure 167	2.22272
To sine of course 50° 58′	9.89028

To find the difference of longitude.

As radius 45°	10.00000
Is to merid. diff. of latitude 203.	2.30750
So is tangent course 50° 58′	10.09111
To difference of longitude 250.4	2.39861

Or thus,

As proper diff. of latitude 135.4	2.13162
Is to departure 167	2.22272
So is merid. diff. of latitude 203	2.30750
	4.53022
	2.13162
To difference of longitude 250.4	2.39860

To find the difference of latitude.

As radius 90°	10.00000
Is to the distance 215	2.33244
So is cosine course 50° 58′	9.79918
To difference of latitude 135.4 .	2.13162

Latitude left ..	49°	30′	N.	Mer. parts	3428
Diff. of lat. 135	2	15	S.		
Latitude in ...	47	15	N.	Mer. parts	3225
				Merid. difference of latitude	203

Longitude left	25°	00′	W.
Difference of longitude 250..	4	10	E.
Longitude in	20	50	W

BY GUNTER.

1st. The extent from the distance 215, to the departure 167, on the line of numbers, will reach from the radius 90°, to the course 50° 58′, on the line of sines.

2dly. The extent from radius 90°, to the complement of the course 39° 02′, on the line of sines, will reach from the distance 215, to the difference of latitude 135.4, on the line of numbers.

3dly. The extent from the radius 45°, to the course 50° 58′, on the line of tangents, will reach from the meridional difference of latitude 203, to the difference of longitude 250.4, on the line of numbers. Or, the extent from the proper difference of latitude 135.4, to the departure 167, will reach from the meridional difference of latitude 203, to the difference of longitude 250.4, on the line of numbers.

Digitized by Google

BY INSPECTION.

Find the course and difference of latitude, as in Case V. Plane Sailing, by seeking in Table II., till the distance and departure are found to correspond in their respective columns, adjoining to which, in the column of latitude, will be found the true difference of latitude, which, if greater than the departure, the course will be found at the top, but if less, the course will be found at the bottom: with this course seek the meridional difference of latitude in the latitude column, adjoining to which, in the departure column, will be found the difference of longitude.

Thus the distance 215, and the departure 167, are found to correspond to a course of about 51°, and a difference of latitude 135.3. Find in this table one half the meridional difference of latitude 101.5, opposite to which, in the departure column, stands 125.1; this doubled gives 250.2, for the difference of longitude, nearly.

Having explained the method of calculating single courses by Middle Latitude and Mercator's Sailing, it now remains to explain the method of calculating compound courses. To do this, you must construct a traverse table, and find the difference of latitude and departure for each course and distance, as in Traverse Sailing, and from thence the whole difference of latitude, departure, and latitude in; with the departure and latitudes, find the difference of longitude and longitude in, as in Case II. of Middle Latitude or Mercator's Sailing.

This method is exact enough for working any single day's work at sea, except in high latitudes, where it will be a little erroneous; in this case the difference of longitude and longitude in, may be calculated for every single course and short distance; but in general this nicety in calculation may be neglected.

To illustrate the method of working compound courses, we shall here work an example by Middle Latitude and Mercator's Sailing.

EXAMPLE.

A ship from Cape Henlopen, in the latitude of 38° 47′ N., longitude 75° 5′ W., sails the following true courses, viz. E. by S. 20 miles, E. N. E. 15 miles, S. E. 26 miles, south 16 miles, W. S. W. 6 miles, N. W. 10 miles, and east 30 miles; required her latitude and longitude.

By constructing the traverse table with these courses and distances, it appears that the ship has made 27.8 miles of southing, and 69.3 miles of easting; and by subtracting the southing from the latitude of Cape Henlopen, there remains the latitude in 38° 19′ N.

TRAVERSE TABLE.

Courses.	*Dist.*	*Diff. of Lat.*		*Departure.*	
		N.	S.	E.	W.
E. by S.	20		3.9	19.6	
E. N. E.	15	5.7		13.9	
S. E.	26		18.4	18.4	
South.	16		16.0		
W. S. W.	6		2.3		5.5
N. W.	10	7.1			7.1
East.	30			30.0	
		12.8	40.6	81.9	12.6
			12.8	12.6	
	Diff. of lat...		27.8	69.3 Dep.	

Cape Henlopen's latitude	38°	47′ N.	Meridional parts	2528
Latitude in............	38	19 N.	Meridional parts	2492
Sum of latitudes.......	77	6		36
Middle latitude.........	38	33		

By inspection of Table II. it appears that the difference of latitude 27.8, and departure 69.3, correspond to a course of 68° nearly, and a distance of 75 miles; and in the same page of the table, opposite to the meridional difference of latitude, found in the column of latitude, stands the difference of longitude 89 miles in the departure column; this being subtracted from the longitude of Cape Henlopen, 75° 5′ W., leaves the longitude in 73° 36′ W., by Mercator's Sailing. Or, with the middle latitude 38° 33′ to 39°, as a course, find the departure 69.3, in the latitude column, opposite to which is 89 in the distance column, which is the difference of longitude by Middle Latitude Sailing; consequently the longitude in is 73° 36′ W., as above.

Thus we see that such examples are performed as in Traverse Sailing, and Case II. of Mercator's or Middle Latitude Sailing, either by inspection, as above, or by the scale of logarithms

QUESTIONS FOR EXERCISE.

Question I. A ship in the latitude of 49° 57′ N., and longitude of 15° 16′ W., sails south-westerly until her departure is 789 miles, and then, by observation, is in the latitude of 39° 20′ N.; required her course, distance, and longitude in.

Answer. Course S. 51° 05′ W., distance 1014 miles, longitude in 33° 50′ W.

Quest. II A ship in the latitude of 42° 30′ N., and longitude of 58° 51′ W., sails S. W. by S. 591 miles; the latitude, and longitude in, are required.

Ans. Latitude in 34° 19′ N., longitude in 65° 51′ W.

Quest. III. A ship from the latitude of 49° 57′ N., and longitude of 30° 00′ W., sails S. 39° W. till she arrives in the latitude of 45° 31′ N.; required the distance run, and longitude in.

Ans. Distance 342.3, longitude in 35° 21′ W.

Quest. IV. A ship from the latitude of 50° 10′ S., and longitude of 30° 00′ E., sails E. S. E. until her departure is 957 miles; required the distance sailed, and the latitude and longitude in.

Ans. Distance 1036 miles, latitude in 56° 46′ S., longitude in 56° 50′ E.

Quest. V. A ship in the latitude of 49° 30′ N., and the longitude of 25° 00′ W., sails south-easterly 645 miles, making 500 miles departure; required the course steered, and the latitude and longitude in.

Ans Course S. 50° 49′ E., latitude in 42° 42′ N., longitude in 12° 57′ W.

Having gone through the necessary problems in Mercator's Sailing, we shall now show how Mercator's Chart may be constructed by means of the Table of Meridional Parts.

To construct a Mercator's Chart to commence at the equator.

Suppose it was required to construct the Chart in the Plate prefixed to this work, which begins at the equator, and reaches to the parallel of 50 degrees, and contains 95 degrees of longitude west from the meridian of Greenwich.

Draw the line AD representing the equator; then take from any scale of equal parts the number of minutes contained in 95 degrees, viz. 5700, which set off from A to D; subdivide this line into 95 equal parts, representing degrees of longitude. Through A and D draw the lines AB, DC, perpendicular to AD, and make each of them equal to 3474, which are the meridional parts, corresponding to 50 degrees. Join BC, which must be subdivided in the same manner as the line AD; and through the corresponding points of the lines AD, BC, must be drawn (at the distance of 10° or 20°) the lines parallel to AB, representing meridians of the earth; these lines must be numbered 0, 10, 20, &c., beginning at the line AB, which represents the meridian of Greenwich. Set off in like manner upon the meridians AB, DC (beginning from the equator AD), the meridional parts corresponding to each degree of latitude from 0° to 50°; and through the corresponding points (at the distance of 10° or 20°) draw lines parallel to the equator AD, to represent the parallels of latitude. Then the upper part of the chart will represent the north, the lower the south, the right hand the east, and the left hand the west (which is generally supposed in charts, unless the contrary is expressly mentioned).

If the chart does not commence at the equator, but is to serve for a certain portion of the globe contained between two parallels of latitude on the same side of the equator, you must draw the meridians as directed in the last example; then subtract the meridional parts of the least latitude of the chart from the meridional parts of the other latitudes, and set off these differences on the extreme meridians; draw lines through the corresponding points, and they will be the parallels of latitude on the chart.

If the chart is to be bounded by parallels of latitude on different sides of the equator, you must draw a line representing the equator, and perpendicular to it draw the lines to represent the meridians, continuing them on both sides of the equator; then set off the parallels of latitude on both sides of the equator, in the same manner as in the first example.

Take from the Table of Latitudes and Longitudes of places the latitude and longitude of each particular place contained within the bounds of the chart, and lay a rule over its latitude, and another crossing that over its longitude; the point where these meet will represent the proposed place upon the chart. The most remarkable point of a sea-coast being thus laid down, lines may be drawn from point to point, which will form the outlines of the sea-coast, islands, &c.; to which may be annexed the depths of water expressed in common Arabian numbers, the time of high water on the full and change days expressed in Roman numbers, the setting of the tide expressed by an arrow, and whatever else may be thought convenient for the chart to contain.

Digitized by Google

This chart is not to be considered as a just representation of the earth's surface, for the figures of islands and countries are distorted towards the poles, as is evident from the construction; but the degrees of latitude and longitude are increased in the same proportion, so that the bearings between places will be the same on the chart as on the globe; and as the meridians are right lines, it follows, that the rhumbs, which form equal angles with the meridians, will be straight lines, which render this projection of the earth's surface much more easy and proper for the mariner's use than any other.

Having the latitude and longitude of a ship or place, to find the corresponding point on the chart.

Rule. · Lay a ruler across the chart in the given parallel of latitude; take in your compasses the nearest distance between the given longitude and the nearest meridian drawn across the chart; put one foot of the compasses in the point of intersection of the ruler and meridian, and extend the other along the edge of the ruler on the same side of the meridian as the place lies, and that point will represent the place of the ship.

If the longitude on the chart be counted from a different meridian from that you reckon from, you must reduce the given longitude to the longitude of the chart, by adding or subtracting the difference of longitude of those meridians, and then mark off the ship's place, as before directed. Or you may draw a meridian line through the place you reckon your longitude from; then measure off the ship's longitude on the equator, and apply it to the edge of the ruler from this meridian, and you will obtain the ship's place.

To find the bearing of any place from the ship.

Rule. Lay a ruler across the given place and the place of the ship; set one foot of the compasses in the centre of some compass near the ruler, and take the nearest distance to the edge of the ruler; slide one foot of the compasses along that edge, keeping the other extended to the greatest distance from the ruler, and observe what point of the compass it comes nearest to, for that will be the bearing required.

To find the distance of any place from the ship.

Rule. Take the distance between the ship and the given place in your compasses, and apply it to the side of the chart or graduated meridian, setting one foot as much above one place as the other is below the other place; the number of degrees between the points of the compasses will be the distance nearly.

When the places bear north and south of each other, this rule is accurate; but when they bear nearly east and west, and the distance is large, it will err considerably; but in general it is exact enough for common purposes; if greater accuracy is required, it is best to find the distance by calculation.

If any one wishes to estimate the distance accurately by the chart, he must proceed in the following manner:—

1. If the place be in the same longitude that the ship is in, then the preceding rule is accurate.

2. If the place be in the same latitude as the ship, or bear east or west, the distance cannot be obtained without calculating it by Case I. of Parallel Sailing.

3. If the place be neither in the same latitude, nor in the same longitude as the ship, the distance must be found in the following manner:—Lay a ruler over both places, and draw through one of them a parallel to the equator; take the difference of latitude between both places in your compasses from the equator; slide one foot on that parallel, keeping the other extended so that both points shall be on the same meridian, and note the point of the ruler which is touched by the other foot of the compasses; take the distance from this point to the given place through which the parallel was drawn, and apply it to the equator, and you will have the sought distance.

The bearing and distance of any two places from each other may be found in the same manner as the bearing and distance of any place from the ship.

EXAMPLE.

Required the bearing and distance between the east end of Long Island and the north part of Bermudas.

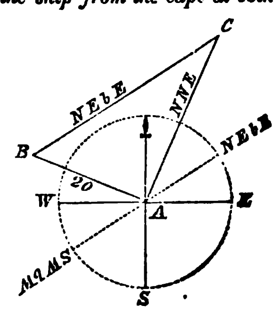
A ruler being laid over both places, as directed in the preceding rule, it will be found to lie parallel to the N. W. by N. and S. E. by S. line; and the distance between the two places being taken in the compasses, and applied to the graduated meridian, will measure about 10 degrees or 600 miles; therefore these places bear from each other N. W. by N and S. E. by S., and their distance is 600 miles, nearly.

Digitized by Google

PROBLEMS USEFUL IN NAVIGATION AND SURVEYING.

PROBLEM I.

Coasting along shore, I saw a cape of land bearing N. N. E., and after sailing W. N. W 20 miles, it bore N. E. by E.; required the distance of the ship from the cape at both stations.



BY PROJECTION.

Describe the compass ESW, and let its centre A represent the place of the ship at the first station; draw the W. N. W. line AB equal to 20 miles, and B will represent the second station. Draw the N. N. E. line AC, of an indefinite length, and the line BC parallel to the N. E. by E. line of the compass; the point of intersection C will represent the place of the cape; and the distance BC, being measured, will be found 36 miles; and AC 30 miles.

BY LOGARITHMS, (BY CASE I. OF OBLIQUE TRIGONOMETRY.)

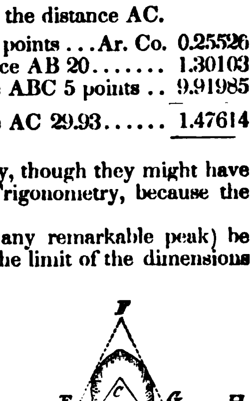
The difference between N. N. E. and W. N. W. is 8 points or 90°, therefore BAC is a right angle; also the difference between the N. E. by E. and N. N. E. is 3 points, equal to the angle ACB; and the difference between the N. E. by E. point and the point opposite to W. N. W. is 5 points, equal to the angle ABC.

To find the distance BC.	
As sine angle ACB 3 pts. Ar. Co.	0.25526
Is to the distance AB 20	1.30103
So is sine angle BAC 8 points..	10.00000
To the distance BC 36.0	1.55629

To find the distance AC.	
As sine ACB 3 points ...Ar. Co.	0.25526
Is to the distance AB 20.......	1.30103
So is sine angle ABC 5 points ..	9.91985
To the distance AC 29.93......	1.47614

The above solutions are by Case I. Oblique Trigonometry, though they might have been done, in this example, by Case II. of Right-angled Trigonometry, because the angle BAC is a right angle.

If the bearings of the middle point C of an island (or any remarkable peak) be determined in this manner, we may, at the same time, find the limit of the dimensions of the island, by measuring with a quadrant or sextant, held in a horizontal position, the angular distances between that middle point and the extremes of the island. For by drawing the lines ADE, AGF, making the angles DAC, GAC, with AC, equal to the angular distances observed at A. and in the same manner by drawing the lines BDG, BEF, making angles with BC equal to the angular distances observed at B, you would obtain the quadrilateral figure DEFG, within which the island is to be placed. If similar observations could be procured at H, they would in general take off the corners at D and F; and observations at I would generally take off the corners at E and G; and by observing the projecting points and coves in the island, while sailing round it, and drawing a figure conformable thereto, within the limiting space thus found, the form and dimensions of the island may be obtained to a considerable degree of accuracy.



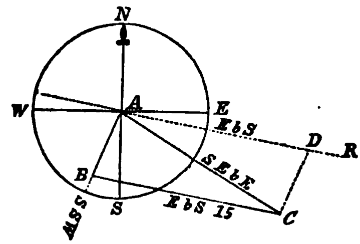
Digitized by Google

PROBLEM II.

Being at sea, we saw two headlands, whose bearing from one another by the chart was W. by N., and E. by S., and the distance 15 miles; the westernmost bore from us S. S. W., and the easternmost S. E. by E.: required our distance from each of them.

BY PROJECTION.

Draw the compass NESW, and through the centre A, draw the E. by S. line AR, the S. S. W. line AB, and the S. E. by E. line AC, and continue the two latter indefinitely; upon the former, AR, take AD equal to 15 miles; through D draw DC parallel to AB, to meet AC in C, and draw CB parallel to AD. Then A will be the place where the headlands B and C were observed; and the distance AB of the westernmost headland, being measured, is found to be 5.8 miles, and the distance AC of the easternmost headland 15 miles.



BY LOGARITHMS.

Between the S. S. W. line AB, and the S. E. by E. line AC, are 7 points = angle BAC; and between the S. E. by E. line AC, and the E. by S. line AD, are 2 points = angle CAD = angle ACB (because AD, BC, are parallel); therefore ACB + BAC = 9 points; and since all three angles ACB, BAC, ABC, are equal to 16 points, the angle ABC is also equal to 7 points; therefore (by *Art.* 39, Geometry) the sides AC, CB, are equal, being opposite to the equal angles ABC, BAC. If these angles had not been equal, the side AC might have been calculated in the same manner as we shall now calculate the side AB.

To find the side AB.

As sine BAC 7 points.........Arith. Comp.	0.00843
Is to BC 15 miles........................	1.17609
So is sine ACB 2 points..................	9.58284
To AB 5.85...............................	0.76736

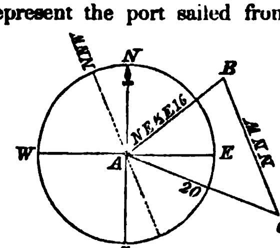
This problem, or the first, may be used for finding the distance of a ship from any headland, &c., when taking a departure from the land.

PROBLEM III.

Two ships sail from the same port; the first sails N. E. ½ E. 16 miles; the second sails easterly 20 miles, and then finds that the first bears N. N. W.: required the course of the second ship, and the distance between the two ships.

BY PROJECTION.

Draw the compass ESW, and let its centre A represent the port sailed from draw the N. E. ½ E. line AB equal to 16 miles; also through B, the line BC, parallel to the N. N. W. line, and continue it indefinitely; take a distance representing 20 miles in your compasses, and putting one foot in A, describe with the other an arc cutting the line BC in C, and join AC. Then B will be the place of the first ship, C that of the second, and AC the course steered by the second ship, which will be nearly E. S. E. ½ E., and BC the distance of the ships 17½ miles.



BY LOGARITHMS.

The course from B to C is S. S. E. (opposite to N. N. W.), and from B to A is S. W. ½ W. (opposite to N. E. ½ E.); the difference between these bearings is 6½ points, equal to 73° 7′, equal to the angle ABC; having this angle and the sides AB, AC, we may find the other angles and side by Cases II. and III. of Oblique Trigonometry, as follows:—

Digitized by Google

To find the angle C.

As the side AC 20 miles......	1.30103
Is to sine ABC 73° 7′.........	9.98087
So is side AB 16 miles........	1.20412
	11.18499
Subtract..............	1.30103
To sine angle C 49° 57′......	9.88396
For N. N. W., add 22 30	

Sum is N. 72° 27′ W., the bearing of A from C; whence the course of the ship from A towards C, is S. 72° 27′ E., or E. S. E. ½ E., nearly.

To find the distance of the ships BC.

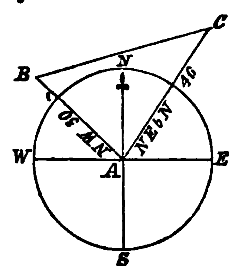
Add the angle C = 49° 57′, to the angle B 73° 7′, we obtain the sum 123° 4′; subtracting this from 180°, leaves the angle CAB 56° 56′.

As sine angle ABC 73° 7′, Ar. Co.	0.01913
Is to the side AC 20 miles......	1.30103
So is sine CAB 56° 56′.........	9.92326
To the side BC 17.5 miles......	1.24342

PROBLEM IV.

Two ships sail from the same port, the one N. W. 30 miles, and the other N. E. by N. 40 miles; required the bearing and distance of the ships from each other.

BY PROJECTION.



Draw the compass NESW, and let its centre A represent the port sailed from; draw the N. W. line AB equal to 30 miles, and the N. E. by N. line AC equal to 40 miles; join BC, which will be the bearing and distance of the two ships; whence the bearing will be found to be W. S. W. ½ W., and the distance 45.1 miles, nearly.

BY LOGARITHMS, (BY CASES IV. V. OF OBLIQUE TRIGONOMETRY.)

Between the N. W. line AB, and the N. E. by N. line AC, there are 7 points, equal to angle BAC; half the supplement of this to 180° is 50° 37½′, equal to half sum of the angles C and B.

To find the angles B, C.

As sum of AB and AC 70..Ar. Co. Log.	8.15490
Is to their difference 10..............	1.00000
So is tangent half sum angles 50° 37½′..	10.08583
To tangent half diff. of angles 9 52½..	9.24073
Sum is angle B............ 60 30	
Difference is angle C....... 40 45	

To find the distance BC.

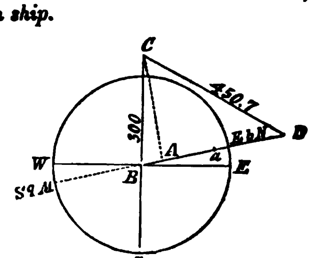
As sine angle B.... 60° 30′ Ar.Co.Log.	0.06030
Is to side AC...... 40	1.60206
So is sine angle A.. 78 45...........	9.99157
To the distance BC 45.1..............	1.65393

To the angle C, equal to 40° 45′, add the angle representing the course from C to A, equal to 33° 45′, the sum is 74° 30′, which is the bearing of B from C, namely, S. 74° 30′ W., or W. S. W. ½ W., nearly.

PROBLEM V.

Two ports bear from each other E. by N. and W. by S., distance 400 miles: a ship from the easternmost sails northerly 450.7 miles; another from the westernmost sails 300 miles, and meets the first: required the course steered by each ship.

BY PROJECTION.



Draw the compass ESW, and let the centre B represent the westernmost port; draw the E. by N. line BD equal to 400 miles, and D will be the easternmost port; with 300 in your compasses, and one foot in B, describe an arc; with 450.7 in your compasses, and one foot in D, describe another arc, cutting the former in C; join DC, BC. Then BC will be the course sailed by the westernmost ship, and DC the course sailed by the easternmost ship.

Digitized by Google

BY LOGARITHMS.

To find the angle CBD.

By Theorem IV. Trigonometry.

Divide the triangle BCD into two right-angled triangles by means of the perpendicular CA, and bisect BD in a; then

As the base BD 400 ......Ar. Co. Log.		7.39794
Is to the sum of BC, CD.....	750.7....	2.87547
So is difference of BC, CD...	150.7....	2.17811
To twice Aa	282.8....	2.45152
Half, or Aa	141.4	
Half BD = Ba = ...	200	
Difference is BA............	58.6	

Then, in the triangle ACB,

As hypotenuse DC 300	2.47712
Is to radius 90°	10.00000
So is AB 58.6	1.76790
To cosine CBD 78° 44′...............	9.29078

By Theorem V. Trigonometry.

CD = 450.7		
BD = 400 .. Ar. Co. Log.		7.39794
BC = 300 .. Ar. Co. Log.		7.52288
Sum...........	1150.7	
Half sum	575.35.........Log.	2.75993
Half sum less CD	124.65.........Log.	2.09569
	Sum....... 2)	19.77644
Half sum.. 39° 22′	.............Cosine	9.88822
2		

Doubled is 78 44 = angle CBD. Having found this angle, we may find either of the others, thus:

To find the angle CDB.

As CD 450.7..............Arith. Comp.	7.34611
Is to sine CBD 78° 44′................	9.99155
So is BC 300.........................	2.47712
To sine CDB 40° 45′	9.81478

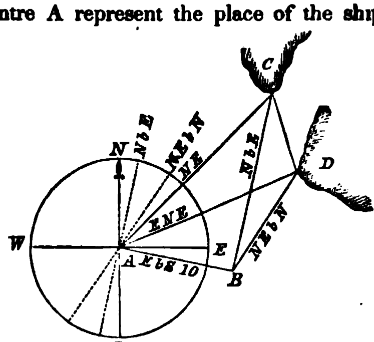
As the angle CBD is 78° 44′, or 7 points nearly, and the course from B to D is E. by N., the course from B to C must be north. The course from D to B being W. by S., or W. 11° 15′ S., and the angle BDC equal to 40° 45′, the bearing of C from D must be W 29° 30′ N., because 40° 45′ — 11° 15′ = 29° 30′

PROBLEM VI.

Coasting along shore, we saw two headlands; the first bore from us N. E., the second E. N. E.; after sailing E. by S. 10 miles, the first bore N. by E., and the second N. E. by N.: required the bearing of the two headlands from each other, and their distance.

BY PROJECTION.

Draw the compass NESW, and let its centre A represent the place of the ship at the first station; draw the E. by S. line AB equal to 10 miles, and B will be the place of the ship at the second station; draw the N. E. line AC, and the E. N. E. line AD; through the point B draw the lines BC, BD, parallel to the N. by E. and N. E. by N. lines, and the points C and D, where they intersect the lines drawn from A to the same headlands, will be the points representing them respectively; join the points C and D; then will CD be the distance of the two headlands, and a line drawn through A parallel to CD will represent the bearing of those places from each other on the compass.



BY LOGARITHMS.

In the triangle ABC, we have all the angles and the side AB to find BC; for the bearings of B and C from A are E. by S., and N. E., the difference being 5 points, equal to BAC; and the bearings of B and A from C are S. by W., and S. W., the difference being 3 points, equal to the angle ACB.

To find the side BC.

As sine of ACB 3 points......Arith. Comp.	0.25526
Is to the side AB 10	1.00000
So is sine angle BAC 5 points.............	9.91985
To BC 14.97.............................	1.17511

In the triangle ABD, we have all the angles and the side AB to find BD; for the bearings of B and A from D are S. W. by S., and W. S. W., the difference being

Digitized by Google

3 points, equal to BDA; and the bearings of B and D from A are E. by S., and E. N. E., the difference being also 3 points, equal to the angle BAD; therefore the angle BAD = BDA, and (by *Art.* 39, Geometry) BD = AB = 10 miles. If these angles had not been equal, we might have calculated the side BD in the same manner as BC.

Now, in the triangle CBD, we have BD = 10, BC = 14.97, and the angle CBD = 22° 30′; for the bearings of C and D from B are N. by E., and N. E. by N., differing 2 points, or 22° 30′; hence we may find the other angles and side CD as in Case IV. of Oblique Trigonometry.

To find the angles BCD, BDC.

As sum of BC, BD, 24.97, Arith. Comp.	8.60258
Is to their difference 4.97	0.69636
So is tang. half sum op. angles 78° 45′..	10.70134
To tangent half diff. of angles 45 1 ..	10.00028

Sum is angle BDC = 123 46
Difference is angle BCD = 33 44, or nearly 3 points; and as the bearing of B from C is S. by W., the bearing of D from C must be S. S. E.

To find the distance CD.

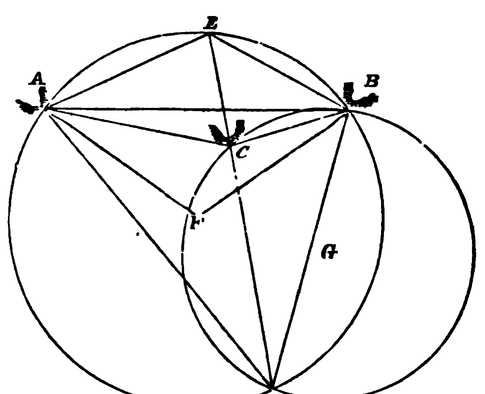
As sine angle BCD 33° 44′, Arith. Comp.	0.25545
Is to side BD 10	1.00000
So is sine angle CBD 22° 30′..........	9.58284
To the distance CD 6.89..............	0.83829

PROBLEM VII.

The bearings and distances of three points of land, A, B, C, *being given, together with the horizontal angles* ADC, CDB, *measured in a boat placed over a shoal at the point* D; *required the bearing and distance of the shoal from any one of the points* A, B, C.

BY PROJECTION.

The sum of the two angles ADC, CDB, is equal to the angle ADB. Make the angles BAF, ABF, each equal to the complement of the angle ADB, and draw the lines AF, BF, which will intersect each other in the point F. Upon F, as a centre, with the radius FA, equal to FB, describe the circle AEBD. Then any point D, of this circumference ADB, may be taken as the vertex of a triangle, whose base is AB, forming an angle ADB, which will satisfy the condition of being equal to the sum of the measured angles ADC, CDB. In the same manner we may find the centre G, of a circle BCD, whose circumference will contain the vertex D, of the triangle DCB, forming an angle at the vertex equal to the measured angle CDB. The point of intersection of these two circles is the place of the shoal at D; whence we easily obtain the distances AD, BD, CD; also the bearings of the shoal from the points A, B, C. Continue the line DC to meet the circle ADB in E.



BY LOGARITHMS.

We have the bearings and distances of the points A, B, C, given from the map, or by previous observations, so that all parts of the triangle ABC are known. In the triangle AEB, we have the angle EAB equal to the observed angle CDB (*Art.* 41 Geometry), also angle EBA equal to the observed angle CDA; the sum of these two angles subtracted from 180°, leaves the remaining angle AEB of the triangle AEB hence we have all the angles, and the base AB of this triangle, to find AE, by Case I. of Oblique Trigonometry. In the triangle AEC, we have AE by the preceding calculation, and AC from the map, also the angle EAC = CAB + EAB = CAB + EDB; so that we have the two sides AE, AC, and the included angle EAC, to find the angle

Digitized by Google

ACE, by Case IV. of Oblique Trigonometry; the supplement of this angle is the value of the angle ACD; adding this angle to the observed angle CDA, and subtracting the sum from 180°, we get the angle CAD. Then in the triangle CAD we have all the angles, and the side AC, to find CD, AD, by Case I. of Oblique Trigonometry. In like manner we may find BD, in the triangle CBD.

EXAMPLE.

Suppose we have given, by the map, AB = 3200 feet, BC = 1330 feet, AC = 1990 feet, angle BAC=12° 34′; also, by observation, CDB=EAB=25°, CDA=EBA=28°; required ACD, CAD, AD, CD, BD.

To find AE, in the triangle AEB.

EAB =	25°		
EBA =	28	....................Sine	9.67161
Sum	53		
	180		
AEB =	127	.......Arith. Comp. Sine	0.09765
AB =	3200	....................Log.	3.50515
AE =	1881	....................Log.	3.27441

To find AEC, ACE, in the triangle AEC.

BAC = 12°34′		AC=1990
EAB = 25 00		AE=1881
Sum 37 34=EAC		AC+AE=3871
180 00		AC—AE= 109

AEC+ACE =	142 26		
½(AEC+ACE)=	71°13′	.....Tangent	10.46839
AC + AE =	3871	...Ar. Co. Log.	6.41218
AC — AE =	109	..........Log.	2.03743
½(AEC—ACE)=	4° 44′	....Tangent	8.91800
½(AEC+ACE)=	71 13		
Sum AEC=	75 57		

Difference ACE= 66 29; the supplement of this angle ACE is equal to ACD = 113° 31′

CDA =	28 00
Sum	141 31
	180 00
CAD =	38 29

To find AD, CD, in the triangle ACD.

As CDA =	28°	....Arith. Comp. Sine	0.32835
Is to AC =	1990	................Log.	3.29885
So is ACD =	113° 31′	............Sine	9.96234
To AD =	3887	................Log.	3.58958

As CDA =	28°	....Arith. Comp. Sine	0.32839
Is to AC =	1990	................Log.	3.29885
So is CAD =	38° 29′	...........Sine	9.79399
To CD =	2638	................Log.	3.42122

To find BD, in the triangle BAD.

BAC =	12° 34′	CDB =	25° 00′
CAD =	38 29	CDA =	28 00
Sum BAD	51 03	ADB =	53° 00

As ADB =	53°	....Arith. Comp. Sine	0.09765
Is to AB =	3200	................Log.	3.50515
So is BAD =	51° 03′	.............Sine	9.89081
To BD =	3116	................Log.	3.49361

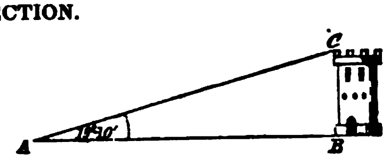
This method becomes defective when the points F, G, approach very near to each other; to avoid this, we must be careful not to take for the place of observation any point which approaches near to the circumference of a circle which passes through the observed points A, C, B; because a very small error in the observed angles might then produce a very great error in the result, or place of the observer. Care must also be taken to have both the angles observed at the same point, without allowing the boat to drift, in which the observations are made.

PROBLEM VIII.

Being 96 *fathoms from the bottom of a tower, I found its altitude above the horizontal line drawn from my eye was* 15° 10′; *required the elevation above that line.*

BY PROJECTION.

Draw the horizontal line AB equal to 96 fathoms, and perpendicular thereto, the line BC; make the angle BAC equal to 15° 10′, and draw AC to cut BC in C; then will BC be the height of the tower, 26 fathoms.



Digitized by Google

BY LOGARITHMS.

As radius 90°	10.00000
Is to the distance AB 96 fathoms	1.98227
So is tangent angle A 15° 10′	9.43308
To the height BC 26.0 fathoms	1.41535

When an object, whose elevation above the horizon is to be determined, is at a very great distance, it will be necessary to notice the correction arising from the curvature of the earth and the refraction, and apply that correction to the height estimated by the above method. Thus, if the angular elevation of a mountain whose base was more distant than the limit of the visible horizon, was observed by an instrument of reflexion, the approximate height must first be obtained, as in the preceding example, and then the correction of that approximate height for the curvature of the earth, refraction, and dip, must be calculated by the following rule, and added to that height · the sum will be the true height above the level of the sea.

Rule. Find in Table X. the number of miles corresponding to the height of the observer above the level of the sea, and take the difference between that number and the distance of the mountain from the observer in statute miles; with that difference enter the same table, and find the height in feet corresponding, which will be the correction to be added to the approximate height to obtain the true height of the mountain above the level of the sea.

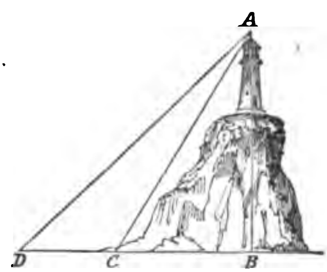
Example. Suppose the distance was 32 statute miles (or 168960 feet), and the observed altitude 1° 2′, the observer being 18 feet above the level of the sea; required the height of the mountain above the same level.

As radius ....Log.	10.00000		M.
Is to distance 168960......Log.	5.22779	Distance of mountain............	32
So is elevation 1° 2′ .....Tang.	8.25616	Table X. 18 feet................	5.61
Approximate height 3048..Log.	3.48395	Difference	26.39
Correction........ 398		Corresponding Corr. Table X.	398ft.

Sum............. 3446 is the true height above the level of the sea.

PROBLEM IX.

I observed the altitude of the top of a tower above the level sand on the sea-shore to be 59°; then, measuring directly from it 98 yards, its elevation was found to be 44°: required the height of the tower.



Let AB represent the height of the tower, C the first station, and D the second; then we have the angle ACB equal to 59°, the angle ADB equal to 44°, the angle DAC = 59° — 44° = 15°.

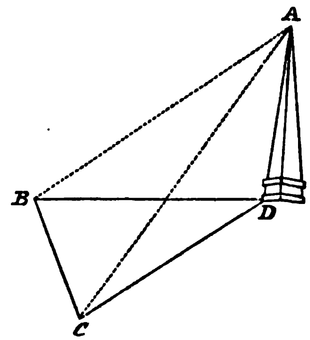
To find the side AC.		To find the height AB.	
As DAC 15° ....Sine	9.41300	As radius ....Log.	10.00000
Is to DC 98.. ....Log.	1.99123	Is to AC 263.0*........Log.	2.42000
So is ADC 44° ....Sine	9.84177	So is ACB 59° ....Sine	9.93307
	11.83300		12.35307
	9.41300		10.00000
To AC 263.0 ....Log.	2.42000	To AB 225.5............Log.	2.35307

* The log. AC, by the preceding operation was found to be 2.42000, differing but a little from the log. of 263.

Digitized by Google

PROBLEM X.

By observation, I found the angle of elevation of a monument, at one station, to be 21° and the horizontal angle, at this station, between the base of the monument and the second station, was 79°; the horizontal angle, at the second station, between the base and the first station, was 69°; the distance between the two stations being 139 yards. required the height of the monument.



Let AD represent the monument, C the first station, B the second; then the vertical angle DCA is 21°; and the horizontal angles BCD equal to 79°, CBD equal to 69°; the sum of these two angles being subtracted from 180°, leaves BDC equal to 32°.

To find the side CD.

As BDC 32°	Sine	9.72421
Is to BC 139	Log.	2.14301
So is CBD 69°	Sine	9.97015
		12.11316
		9.72421
To CD 244.9		2.38895

To find the height AD.

As radius	Log.	10.00000
Is to CD 244.9*	Log.	2.38895
So is ACD 21°	Tang.	9.58418
To AD 94	Log.	1.97313

PROBLEM XI.

Sailing towards the land, I discovered a light-house just appearing in the horizon, my eye being elevated 20 feet above the sea; it is required to find the distance of the light-house, supposing it to be elevated 200 feet above the surface of the sea.

The solution of this problem depends on the uniform curvature of the sea, by means of which all terrestrial objects disappear at certain distances from the observer. These distances may be computed by means of Table X., in which the elevation in feet is given in one column, and the distance at which it is visible is expressed in statute miles in the other column. If the place from which you view the object be elevated above the horizon, you must *add together the distances corresponding to the height of the observer and the height of the object*; the sum will be the greatest distance at which that object is visible from the observer; this process being similar to that in Problem VIII.

In the present example, the height of the observer was 20 feet, and the height of the object 200 feet.

In Table X. opposite 20 feet is 5.92 miles.
200 feet 18.71

Distance .... 24.63 statute miles, of about 69½ to a degree; the distance in nautical leagues, of 20 to a degree, being about 7.

PROBLEM XII.

A man, being on the main-top-gallant-mast of a man-of-war, 200 feet above the water. sees a 100 gun ship she had engaged the day before, hull to; how far were those ships distant from each other?

A ship of 100 guns, or a first-rate man-of-war, is about 60 feet from the keel to the rails, from which deduct about 20, leaves 40 for the height of her quarter-deck above water. Now, a ship is seen hull to when her upper works just appear

In Table X. opposite 200 feet stand 18.71
40 feet 8.37

Distance .... 27.08 miles.

* The log. of CD. by the preceding operation. was found to be 2.38895. differing but a little from the log. of 244.9

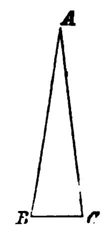
PROBLEM XIII.

Upon seeing the flash of a gun, I counted 30 seconds, by a watch, before I heard the report; how far was that gun from me, supposing that sound moves at the rate of 1142 feet per second?

The velocity of light is so great, that the seeing of any act done, even at the distance of a number of miles, is instantaneous; but, by observation, it is found that sound moves at the rate of 1142* feet per second, or about one statute mile in 4.6 seconds: consequently the number of seconds elapsed between seeing the flash and hearing the report being divided by 4.6, will give the distance in statute miles. In the present example, the distance was about 6½ miles, because 30 divided by 4.6 gives 6½ nearly.

PROBLEM XIV.

To find the difference between the true and apparent directions of the wind.



Suppose that a ship moves in the direction CB from C to B, while the wind moves in its true direction from A to B; the effect on the ship will be the same as if she be at rest, and the wind blow in the direction AC with a velocity represented by AC; the velocity of the ship being represented by BC. In this case, the angle BAC will represent the difference between the true and the apparent directions of the wind; the apparent being more ahead than the true, and the faster the vessel goes, the more ahead the wind will appear to be. We must, however, except the case where the wind is directly aft, in which case the direction is not altered.

It is owing to the difference between the true and apparent directions of the wind, that it appears to shift its direction by tacking ship; and if the difference of the directions be observed when on different boards (the wind on both tacks being supposed to remain constant, and the vessel to have the same velocity and to sail at the same distance from the wind), the half difference will be equal to the angle BAC. By knowing this, together with the velocity of the ship BC, and the angle BCA, we may obtain the true velocity of the wind; or, by knowing the velocity of the wind and of the ship, and the apparent direction of the wind, we may calculate the difference between the true and the apparent directions of the wind.

Thus, if the velocity of a ship represented by BC be 7 miles per hour, that of the wind represented by AB 27 miles per hour, and the angle of the vessel's course with the apparent direction of the wind BCA equal to 7½ points; the difference between the true and apparent directions of the wind will be obtained by drawing the line BC equal to 7 miles, taken from any scale of equal parts, and making the angle BCA equal to 7½ points; then, with an extent equal to 27 miles, taken from the scale, and with one foot in B, describe an arc to cut the line AC in A; join AB; then the angle BAC, being measured, will be the required difference between the true and apparent directions of the wind.

BY LOGARITHMS.

As AB 27 miles	........Arith. Comp. Log.	8.56864
Is to BCA 7½ points	...........Log. Sine	9.99790
So is BC 7 miles	..................Log.	0.84510
To BAC 14° 57′	...............Log. Sine	9.41164

So that, in this case, the difference between the true and apparent directions of the wind is about 1¼ points; and, by tacking ship and sailing on the other board, as above mentioned, the wind will appear to change its directions above 2½ points.

PROBLEM XV.

To measure the height of a mountain by means of the heights of two barometers, taken at the top and bottom of the mountain.

Procure two barometers, with a thermometer attached to each of them, in order to ascertain the temperature of the mercury in the barometers, and two other thermometers, of the same kind, to ascertain the temperature of the air. Then one observer at the top of the mountain, and another at the bottom, must observe, at the same time,

* The velocity of sound at 32° Fahrenheit is 1090 feet per second, and for each additional degree of heat add 1.08 to this velocity.

Digitized by Google

the heights of the barometers, and the thermometers attached thereto, and the heights of the detached thermometers, placed in the open air, but sheltered from the sun. Having taken these observations, the height of the upper observer, above the lower, may be determined by the following rule, which is adapted to a scale of English inches and to Fahrenheit's thermometer:—

RULE. Take the difference of the logarithms of the observed heights of the barometers at the two stations, considering the first four figures, exclusive of the index, as whole numbers, the remainder as decimals; to this difference must be applied the product of the decimal 0.454, by the difference of the altitudes of the two attached thermometers, by subtracting, if the thermometer be highest at the lowest station, otherwise adding: the sum or difference will be the approximate height in English fathoms. Multiply this by the decimal 0.00244, and by the difference between the mean of the two altitudes of the detached thermometers and 32°; the product will be a correction, to be added to the approximate height when the mean altitude of the two detached thermometers exceeds 32°, otherwise subtracted: the sum or difference will be the true height of the upper above the lower observer in English fathoms, which, being multiplied by 6, will be the height in feet.

EXAMPLE.

Suppose the following observations were taken at the top and at the bottom of a mountain; required its height in fathoms.

Attached Thermometer.	*Detached Thermometer.*	*Barometer.*
Obs. at lower station ....57°	56	29.68 inches......Log. 14724.6
upper station........43	42	25.28............Log. 14027.8
Difference 14	Mean.......49	Difference 696.8
	32	0.454 × 14..................6.4
	Difference...17	Approximate height......690.4
		690.4 × 17 × 0.00244......28.6
		Height in fathoms......719.0

University of Michigan

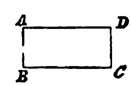
MENSURATION.

PROBLEM I.

To find the area of a parallelogram.

Rule. Multiply the base by the perpendicular height; the product will be the area.

Note. If both dimensions are given in feet, inches, &c., the product will be the area, expressed in square feet, square inches, &c., respectively. If one of the dimensions be given in feet and the other in inches, the product, divided by 12, will be the answer in square feet. If both dimensions are given in inches, the product will be square inches, which, being divided by 144, will be the answer in square feet. The same is to be understood in finding the area of other surfaces.



Example I. Suppose the base BC of the rectangular parallelogram ABCD is 7 feet, and the perpendicular AB 3 feet; required the area.

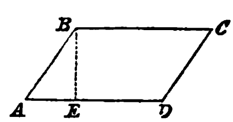
The product of the base 7 feet by the perpendicular 3 feet gives the area 21 square feet.

Example II. Suppose ABCD is a board whose length BC is 22 feet, and breadth AB is 14 inches; required the number of square feet.

The product of the base 22 feet by the breadth 14 inches is 308; this, divided by 12, gives $25\frac{2}{3}$ square feet, the sought area.

Example III. If BC be 25 inches, and AB 20 inches, required the area in square feet.

The product of the base 25 inches by the perpendicular 20 inches gives 500, which, divided by 144, gives the area 3.47 or $3\frac{47}{100}$ square feet.



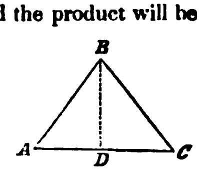
Example IV. Given the base AD of the oblique angular parallelogram ABCD, equal to 30 feet, and the perpendicular height BE 15 feet; required the area of the parallelogram.

Multiply the base 30 feet by the perpendicular 15 feet; the product 450 is the area in square feet.

PROBLEM II.

To find the area of a triangle.

Rule. Multiply the base by half the perpendicular height, and the product will be the area required.



Example. Given the base AC 30 feet, and the perpendicular BD 20 feet; required the area of the triangle.

The base 30 multiplied by half the perpendicular 10 gives the area 300 square feet.

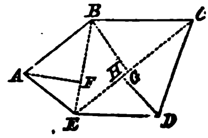
PROBLEM III.

To find the area of any regular right-lined figure.

Rule. Reduce the figure to triangles, by drawing diagonals therein; then find the area of each triangle, and the sum of them will be the area of the proposed figure. Or, instead of finding the area of each triangle separately, you may find, at one operation, the area of two triangles, having the same diagonal, by multiplying the diagonal by half the sum of the perpendiculars let fall thereon.

Digitized by Google

Example. Required the area of the figure ABCDE, in which CE = 33 feet BE = 22 feet, and the perpendicular AF = 13 feet, BG = 14 feet, and DH = 12 feet.



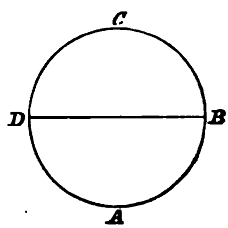
The diagonal BE, 22 feet, multiplied by half the perpendicular AF, 6.5 feet, gives the area of the triangle ABE, 143 square feet; and the diagonal CE, 33 feet, multiplied by half the sum of the perpendiculars BG, DH, 13 feet, gives the area of the figure BCDE, 429 feet; this, added to the triangle ABE, 143 feet, gives the whole area 572 square feet.

PROBLEM IV.

To find the area of a circle.

Rule. Multiply the square of the diameter of the circle by the quantity 0.7854, and you will have the sought area.

Note. Instead of multiplying by 0.7854, you may multiply by 11 and divide by 14; the quotient will be the area nearly. This quantity, 0.7854, represents the area of a circle whose diameter is 1; the circumference of the same circle being 3.1416 nearly. The proportion of the diameter to the circumference is expressed in whole numbers by the ratio of 7 to 22 nearly, or more exactly by 113 to 355.*



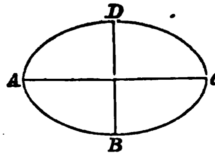
Example. Required the area of a circle ABCD, whose diameter BD is 10.6 feet.

The diameter 10.6 multiplied by itself and by 0.7854 gives the sought area, 88.247544 square feet.

PROBLEM V.

To find the area of an ellipsis.

Rule. Multiply the longest diameter by the least, and the product by 0.7854; this last product will be the area required.



Example. Required the area of an ellipsis ABCD, whose longest diameter AC is 12 feet, and the shortest diameter BD 10 feet.

The product of the two diameters is $12 \times 10 = 120$; this, multiplied by 0.7854, gives the sought area, 94.2480 square feet.

The area of a sector of a circle may be found by means of the whole area of the circle obtained in Problem IV., by saying, As 360 degrees is to the angle contained between the two legs of the sector, so is the whole area of the circle to the area of the sector.

There are various regular solids. The most noted are the following:—(1.) A *Cube*, which is a figure bounded by six equal squares. (2.) A *Parallelopiped*, which is a solid terminated by six quadrilateral figures, of which the opposite ones are equal and parallel. (3.) A *Cylinder*, which is a figure formed by the revolution of a rectangular parallelogram about one of its sides. (4.) A *Pyramid*, which is a solid decreasing gradually from the base till it comes to a point. There are various kinds of pyramids, according to the figure of their bases. Thus, if the base be a triangle, the solid is called a *triangular pyramid*; if a parallelogram, a *parallelogramic pyramid*; and if a circle, a *circular pyramid*, or simply a *cone*. The point in which the pyramid ends is called the *vertex*, and a line drawn from the vertex perpendicular to the base is called the height of the pyramid.

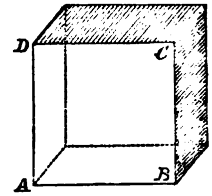
* This ratio may be easily remembered by observing that, if the first three odd numbers, 1, 3, 5, are repeated twice, they will produce the quantity 113355; the three first figures of which make the first term of the ratio, and the three last the last term of the ratio.

Digitized by Google

PROBLEM VI.

To find the solidity of a cube.

RULE. Multiplying the length of a side of the cube by itself, and the product by the same length, gives the solidity required; which will be expressed in cubic feet if the dimensions be given in feet, but in cubic inches if the dimensions be given in inches, &c.



EXAMPLE. If the side AB of the cube be 6.3 feet, it is required to determine the solidity.

The product of 6.3 by 6.3 is 39.69; this, multiplied again by 6.3, gives the solidity 250.047 cubic feet.

PROBLEM VII.

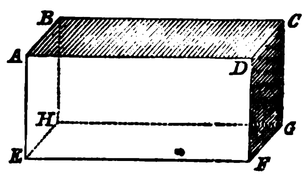
To find the solidity of a rectangular parallelopiped.

RULE. Multiply the length, breadth, and depth, into each other; the product will be the solidity required.

EXAMPLE.

Suppose, in the parallelopiped ABCDFGHE, the length EF is 36 feet, the breadth FG 16 feet, and the depth DF 12 feet; it is required to find the solidity.

The product of the length 36 by the breadth 16 is 576; this, multiplied by the depth 12, gives the solidity 6912 cubic feet.



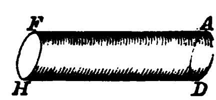
PROBLEM VIII.

To find the solidity of a cylinder.

RULE. Multiply the square of the diameter of the base by the length, and this product by the constant quantity 0.7854; the last product will be the solidity required.

EXAMPLE. Required the solidity of a cylinder ADHF, whose length DH is 13 feet, and diameter of the base AD 11 feet.

The diameter 11, multiplied by itself and by the length 13, gives 1573, which, being multiplied by 0.7854, gives the solidity in cubic feet 1235.4342.



PROBLEM IX.

To find the solidity of a grindstone.

Grindstones, in the form of cylinders, are sold by the *stone* of 24 inches diameter and 4 inches thick. The number of stones that any one contains, may be obtained by the following rule.

RULE. Multiply the square of the diameter in inches by the thickness in inches, and divide the product by 2304, and you will have the number of *stones* required.

EXAMPLE. Required the number of *stones* in a grindstone whose diameter is 36 inches, and thickness 8 inches.

The square of the diameter 36 is 1296, which, being multiplied by the thickness 8 gives 10368. This, divided by 2304, gives 4.5, or 4½ stones, the solidity required.

This problem may be solved by means of the line of numbers on Gunter's Scale, in a very expeditious manner, by the following rule.

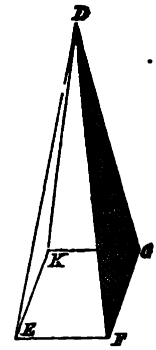
RULE. Extend from 48 to the diameter; that extent, turned over twice the same way, from the thickness, will reach to the number of stones required.

Thus, in the preceding example, the extent from 48 to the diameter 36, turned over twice, from the thickness 8, will reach to 4.5, or 4½, which is the number of stones sought.

Digitized by Google

PROBLEM X.

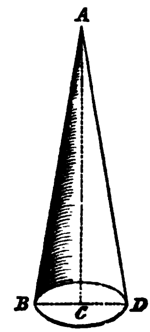
To find the solidity of any pyramid or cone.



RULE. Multiply the area of the base by one third of the perpendicular height of the pyramid or cone; the product will be the solidity required.

EXAMPLE I. If the pyramid have a square base, the side of which is 4 feet, and the perpendicular height 6 feet, it is required to determine the solidity.

The area of the base is $4 \times 4 = 16$ square feet; this, being multiplied by one third of the height, or 2 feet, gives 32 feet, the solidity required.



EXAMPLE II. If the diameter of the base of a cone be 10.6 feet, and the perpendicular height 30 feet, it is required to find the solidity.

The area of this base was found in Problem IV. equal to 88.247544; this, multiplied by one third of the height, or 10 feet, gives the solidity required, equal to 882.47544 cubic feet.

Having obtained, by the foregoing rules, the number of cubic feet in any body, you may find the corresponding number of tons by dividing the number of cubic feet by 40, which is the number of cubic feet contained in one ton. Thus, the solidity of the above-mentioned cone, 882.47544, being divided by 40, gives 22.061886, which is the number of tons in that cone

Digitized by Google

GAUGING.

Having found the number of cubic inches in any body, by the preceding rules, you may thence determine the content in gallons, bushels, &c., by dividing that number of cubic inches by the number of cubic inches in a gallon, bushel, &c., respectively.

A *wine gallon*, by which most liquors are measured, contains 231 cubic inches. A *beer gallon*, by which beer, ale, and a few other liquors, are measured, contains 282 cubic inches. A *bushel* of corn, malt, &c., contains 2150.4 cubic inches; this measure is subdivided into 8 gallons, each of which contains 268.8 cubic inches.

In all the following rules, it will be supposed that the dimensions of the body are given in inches, and decimal parts of an inch.

PROBLEM I.

To find the number of gallons or bushels in a body of a cubic form.

Rule. Divide the cube of the sides by 231, the quotient will be the answer in wine gallons; or by 282, and the quotient will be the answer in beer gallons; or by 2150.4, and the quotient will be the number of bushels.

Example. Required the number of wine gallons contained in a cubic cistern, the length of whose side is 62 inches.

Multiplying 62 by itself, and the product again by 62, gives the solidity 238328 which, being divided by 231, gives the content $1031\frac{3}{4}$ wine gallons.

PROBLEM II.

To find the number of gallons or bushels contained in a body of the form of a rectangular parallelopiped. (See figure of Problem VII. of *Mensuration.*)

Rule. Multiply the length, breadth, and depth, together; divide this last product by 231 for wine gallons, by 282 for beer gallons, or by 2150.4 for bushels.

Example. Required the number of wine gallons contained in a cistern ABCDFGHE (see fig. Prob. VII. of *Mensuration*) of the form of a parallelopiped, whose length EF is 66 inches, its breadth FG 35 inches, and its depth DF 24 inches.

Multiplying the length 66 by the breadth 35 gives 2310; multiplying this by the depth 24 gives the solidity 55440, which, being divided by 231, gives 240 wine gallons.

PROBLEM III.

To find the number of gallons or bushels contained in a body of cylindrical form.

Rule. Multiply the square of the diameter by the height of the cylinder, and divide the product by 294.12; the quotient will be the number of wine gallons. If you divide by 359.05, the quotient will be the number of ale gallons; and if you divide by 2738, the quotient will be the number of bushels.

Note. These divisors are found by dividing 231, 282, and 2150.4, by 0.7854 respectively.

Example. Required the number of wine gallons contained in the cylinder AFHD (see the fig. of Problem VIII. of *Mensuration*), the diameter AD of its base being 26 inches, and length DH 18 inches.

The diameter 26 multiplied by itself gives 676; multiplying this by the length 18 gives the solidity 12168, which, being divided by 294.12, gives the answer 41 wine gallons nearly.

Digitized by Google

PROBLEM IV.

To find the number of gallons or bushels contained in a body of the form of a pyramid or cone. (See figures of Problem X. of *Mensuration.*)

RULE. Multiply the area of the base of the pyramid or cone by one third of its perpendicular height; the product, divided by 231, will give the answer in wine gallons If it be divided by 282, the quotient will be the number of beer gallons; or by 2150.4, the quotient will be the number of bushels.

EXAMPLE. Required the number of beer gallons contained in a pyramid DEFGK (see fig. Prob. X. Example I.), whose base is a square EFGK, a side of which, as EF, is equal to 30 inches, and the perpendicular height of the pyramid is 60 inches.

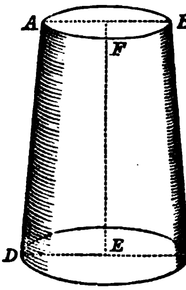
The square of 30 is the area of the base 900; this, being multiplied by one third of the altitude 20, gives the solidity 18000, which, being divided by 282, gives the answer in beer gallons 63.8.

PROBLEM V.

To find the number of gallons or bushels contained in a body of the form of a frustum of a cone. (See the figure below.)

RULE. Multiply the top and bottom diameters together, and to the product add one third of the square of the difference of the same diameters; multiply this sum by the perpendicular height, and divide the product by 294.12 for wine gallons, by 359.05 for ale gallons, or by 2738 for bushels.

A B F E D C



EXAMPLE. Given the diameter CD of the bottom of a frustum of a cone 36 inches, the top diameter AB = 27 inches, and the perpendicular height EF 50 inches; required the contents in wine gallons.

The product of the two diameters, 36 and 27, is 972; their difference is 9, which, being squared and divided by 3, gives 27; adding this to 972 gives 999, which, being multiplied by the height 50, gives the solidity 49950; dividing this by 294.12 gives the content in wine gallons 169.8.

PROBLEM VI.

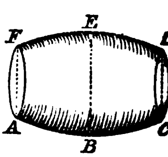
To gauge a cask.

To gauge a cask, you must measure the head diameters, AF, CD, and take the mean of them when they differ; measure also the diameter BE at the bung (taking the measure within the cask); then measure the length of the cask, making due allowance for the thickness of the heads. Having these dimensions, you may calculate the content, in gallons or bushels, by the following rule:—

RULE. Take the difference between the head and bung diameters; multiply this by 0.62, and add the product to the head diameter; the sum will be the mean diameter; multiply the square of this by the length of the cask, and divide the product by 294.12 for wine gallons, by 359.05 for beer gallons, or by 2738 for bushels.

The quantity 0.62 is generally used by gaugers in finding the mean diameter of a cask. But if the staves are nearly straight, it will be more accurate to take 0.55, or less;* if, on the contrary, the cask is full on the quarter, it will be best to take 0.64 or 0.65.

E F D A C B



EXAMPLE. Given the bung diameter EB = 34.5 inches, the head diameter AF = CD = 30.7 inches, and the length 59.3 inches; required the number of wine gallons this cask will hold.

The difference of the two diameters, 34.5 and 30.7, is 3.8; this being multiplied by 0.62, gives 2.4 nearly, to be added to the head diameter 30.7 to obtain the mean diameter 33.1. The square of 33.1 is 1095.61; multiplying this by the length 59.3, gives the solidity 64969.673; dividing this by 294.12, gives the content in wine gallons 220.9.

* In the example to Problem V. preceding (which may be esteemed as the half of a hogshead with staves perfectly straight), the multiplier is only 0.51. For this, being multiplied by 9 (the difference between AB and CD), produces 4.59 or 4.6 nearly; adding this to 27 gives 31.6, whose square, being multiplied by 50, and the product divided by 294.12, gives 170 gallons nearly.

Digitized by Google

To gauge a cask by means of the line of numbers on Gunter's Scale, or that on the Callipers used by gaugers.

Make marks on the scale at the points 17.15, 18.95, and 52.33, which are the square roots of 294.12, 359.05, and 2738, respectively. A brass pin is generally fixed on the callipers at each of these points, which are called the *gauge* points. Having prepared the scale in this manner, you may calculate the number of gallons or bushels by the following rule:—

Rule. Extend from 1 towards the left hand to 0.62 (or less, if the staves be nearly straight); that extent will reach from the difference between the head and bung diameters to a number to the left hand, which is to be added to the head diameter to get the mean diameter; then put one foot of the compasses upon the gauge point (which is 17.15 for wine gallons, 18.95 for ale gallons, and 52.33 for bushels), and extend the other to the mean diameter; this extent, turned over twice the same way, from the length of the cask, will give the number of gallons or bushels respectively.

In the preceding example, the extent from 1 to 0.62 will reach from 3.8 to 2.4 nearly, which, being added to 30.7, gives the mean diameter 33.1; then the extent from the gauge point 17.15 to 33.1, being turned over twice from the length 59.3, will reach to 220.8 wine gallons.

If we use the gauge point 18.95, the answer will be in ale gallons; and if we use 52.33, the answer will be in bushels.

SURVEYING.

LAND is generally measured by a chain of 66 feet in length, divided into 100 equal parts called *links*, each link being 7.92 inches.

A *pole* or *rod* is $16\frac{1}{2}$ feet, or 25 links, in length. Hence a square pole contains $272\frac{1}{4}$ square feet, or 625 square links.

An *acre* of land is equal to 160 square poles, and therefore contains 43560 square feet, or 100,000 square links.

To find the number of square poles in any piece of land, you may take the dimensions of it in feet, and find the area in square feet, as in the preceding problems; then divide this area by 43560, and the quotient will be the number of acres; or by 272.25, and the quotient will be the number of square poles. If the dimensions be taken in links, and the area be found in square links, you may obtain the number of acres by dividing by 100000 (that is, by crossing off the five right-hand figures), and the number of square poles may be obtained by dividing by 625.

PROBLEM I.

To find the number of acres and poles in a piece of land in the form of a rectangular parallelogram.

RULE. Multiply the base by the perpendicular height, and divide by 625 if the dimensions be taken in links, or by 272.25 if they be taken in feet; the quotient will be the number of poles. Dividing this by 160, we get the number of acres.

EXAMPLE. Suppose the base BC (see the figure of Ex. I. Prob. I. of *Mensuration*) of the rectangular parallelogram ABCD is 60 feet, and the perpendicular AB 25 feet required the area in poles.

The product of the base 60 by the perpendicular 25, gives the content 1500 square feet; and by dividing it by 272.25, we obtain the answer in square poles 5.5, nearly.

PROBLEM II.

To find the number of acres and poles in a piece of land in the form of an oblique-angular parallelogram. (See the figure of Prob. I. Ex. IV. of *Mensuration.*)

RULE. This area may be found in exactly the same manner as in the preceding problem, by multiplying the base AD by the perpendicular height BE, and dividing by 625 when the dimensions are taken in links, or by 272.25 when taken in feet; the quotient will be the answer in poles, which, being divided by 160, will give the answer in acres.

EXAMPLE. Suppose the base AD is 632 links, and the perpendicular BE 326 links; required the number of poles.

Multiply the base, 632 links, by the perpendicular, 326 links; the product 206032, divided by 625, gives the answer in poles 329.7.

PROBLEM III.

To find the number of acres and poles in a piece of land of a triangular form.

RULE. Multiply the base by the perpendicular height, and divide the product by 1250 when the dimensions are given in links, or by 544.5 when they are given in feet; the quotient will be the answer in poles.

Note. Instead of dividing by 1250, you may multiply by 8 and cross off the four right-hand figures.

Digitized by Google

EXAMPLE. Given the base AC (see figure of Problem II. of *Mensuration*) equal to 300 feet, and the perpendicular BD 150 feet; required the area in poles.

Multiply the base 300 by the perpendicular 150; the product 45000, divided by 544.5, gives the answer in poles 82.6.

PROBLEM IV.

To find the number of acres and poles in a piece of land of any irregular right-linea figure.

RULE. Find the area, as in Problem III. of *Mensuration*, by drawing diagonals, and reducing the figure to triangles; the base of each triangle being multiplied by the perpendicular (or by the sum of the perpendiculars falling on it), and the sum of all these products divided by 1250 when the dimensions are given in links, but by 544.5 when in feet, will give the area of the figure in poles.

EXAMPLE. Suppose that a piece of land is of the same form as the figure in Prob. III. of *Mensuration*, and that BE = 22 feet, CE = 33 feet, AF = 13 feet, BG = 14 feet, and DH = 12 feet; it is required to find the area in poles.

The product of BE 22 feet, by AF 13 feet, gives double the triangle ABE 286 square feet; and the diagonal CE 33 feet, multiplied by the sum of the perpendiculars BG, DH, 26 feet, gives double the figure BCDE, 858 square feet; the sum of this and 286, being divided by 544.5, gives the area 2.1 or $2\frac{1}{10}$ poles.

To find the content of a field by the Table of Difference of Latitude and Departure.

This method is simple, and much more accurate than by projection, the boundaries being straight lines whose bearings and lengths are known. The rule for making these calculations is as follows:—

RULE.

1. Begin at the western point of the field, as at the point A in the figure Prob. III. of *Mensuration*, for a point of departure; and mark down, in succession, the bearings and lengths of the boundary lines AB, BC, &c., as courses and distances in a traverse table. Find the corresponding differences of latitude and departure by Table I. or II. (or by logarithms), and enter them in their respective columns N. S. E. W. as in the adjoined table.

Courses.	*Dist.*	N.	S.	E.	W.	*Mer. Dist.*	M.	*North Areas.*	*South Areas.*
N. 58° E.	19.	10.1		16.1		16.1	16.1	162.61	
E. 6 S.	20.		2.1	19.9		36.0	52.1		109.41
S. 17 W.	20.		19.1		5.8	30.2	66.2		1264.42
W.	20.				20.0	10.2	40.4		0
N. 42° 35′ W.	15.1	11.1			10.2	0.0	10.2	113.22	
		21.2	21.2	36.0	36.0			275.83	1373.83
									275.83
									1098.
								Half,	549.

2. Find the departures or meridian distances of the points B, C, &c. from the point A, by adding the departures when east, but subtracting when west, and mark them respectively against the bearings, in the column of meridian distance.

3. Place in the first line of the column M the first meridian distance 16.1, and, in the following lines, the sum of the meridian distance which stands on the same line and that immediately above it. Thus on the second line, I put 52.1, which is equal to the sum of 16.1 and 36.0. On the third line, 66.2 = 36.0 + 30.2, &c.

4. Multiply the numbers in the column M by the differences of latitude in the same horizontal line, and place the product in the column of areas marked north or south, according as the difference of latitude is north or south. Thus in the first number in the column M is 16.1, which, being multiplied by the corresponding difference latitude 10.1 N., produces the north area 162.61. The second value of M 52.1, multiplied by the second difference of latitude 2.1 S., produces the south area 109.41. The third values 66.2 and 19.1 S produce the south area 1264.42. The fourth difference of

latitude is 0, which, being multiplied by the fourth meridian distance 40.4, produces 0 for the corresponding area, as is the case whenever the bearing is east or west, &c.

5. Add up all the north and all the south areas; half their difference will be the area of the field in square measures of the same name as those made use of in measuring the lines, whether feet, links, or chains, &c. Thus the sum of all the north areas is 275.83, that of the south 1373.83; their difference is 1098, half of which is 549 square feet, the area of the given field.

It may be observed that the bearings and lengths of the boundary lines in this example, are not exactly the same as those in Problem III. of *Mensuration*, which is the reason of the difference between the area above calculated and that found in Problem III. by dividing the field into triangles.

If it be necessary, the differences of latitude and departure may be taken to one decimal place farther, by entering the table with ten times the length 19, 20, &c., and taking one tenth of the corresponding differences of latitude and departure.

In the above calculations we have supposed the survey to have been made with accuracy, in which case the sums of the differences of latitude in the columns N. S. must be equal to each other; also the sums of the departures in the columns E. W. This is the case in the above example, where the sum of the differences of latitude is 21.2, and the sum of the departures 36.0: but it most frequently happens that the numbers do not agree; in which case the work must be carefully examined, and if no mistake be found, and the error be great, the place must be surveyed again; but if the error be small, it ought to be apportioned among all the differences of latitude and departure, in such manner as to produce the required correction with the least possible changes in the given numbers. The method of doing this was explained by me in the fourth number of the Analyst, in answer to a prize question of Professor Patterson, and is as follows:—Find the error in latitude, or the difference between the sums of southing and northing; also the sum of the boundary lines, AB, BC, &c. Then say, As this sum is to the error in latitude, so is the length of any particular boundary to the correction of the corresponding difference of latitude, additive if in the column whose sum is the least, otherwise subtractive. The corrections of the departure are found by the same rule, except changing difference of latitude into departure. Thus, in the adjoined example, the sum of the boundary lines is 161.6, the error of latitude is 0.10, and of departure 0.08;

Bearings.	*Lengths.*	N.	S.	E.	W.	*Corrections.*		*Corrected Values.*			
						N.	E.	N.	S.	E.	W.
N. 45° E.	40.	28.28		28.28		0.02	0.02	28.30		28.30	
S. 30 W.	25.		21.65		12.50	.02	.01		21.63		12.49
S. 5 E.	36.		35.86	3.14		.02	.02		35.84	3.16	
W.	29.6				29.60	.02	.01	0.02			29.59
N. 20 E.	31.	29.13		10.60		.02	.02	29.15		10.62	
	161.6	57.41	57.51 57.41	42.02	42.10 42.02	0.10	0.08	57.47	57.47	42.08	42.08
		Error,	.10	Error,	.08						

and the corrections of the difference of latitude and departure are found by the following proportions:—

Latitude.	*Departure.*
161.6 : 0.10 :: 40 : 0.02*	161.6 : 0.08 :: 40 : 0.02
:: 25 : 0.02	:: 25 : 0.01
:: 36 : 0.02	:: 36 : 0.02
:: 29.3 : 0.02	:: 29.6 : 0.01
:: 31 : 0.02	:: 31 : 0.02

The first correction of latitude 0.02 is to be added to the first latitude 28.28, because it is in the column whose sum 57.41 is less than the other 57.51, so that the first

* The boundary lines in this example are so nearly of an equal length, that the correction of the difference of latitude (taken to the nearest decimal) is 0.02 for each of them; but in general they will be different. The table of difference of latitude and departure may be made use of in finding these corrections, thus:—Seek in the table till the first term 161.6 (or 162) is found in the distance column to correspond to the second term 0.10 (or 10) in the departure column; thus opposite the third term 40, 25, 36, &c., will be the sought corrections, as is evident.

Digitized by Google

corrected difference of latitude is 28.30. The second is the difference between 21.65 and the second correction 0.02, because 21.65 is in the greatest column; the corrected value is therefore 21.63. The third is found in the same manner to be 35.86 — 0.02 = 35.84. The fourth corrected difference of latitude is simply the fourth correction 0.02 placed in the column N, because the sum in that column, 57.41, is the least, and the fourth difference of latitude in the original table is 0. The fifth is the sum of 29.13, and the fifth correction 0.02, making 29.15. These are placed in their proper columns in the corrected values. In a similar manner the first departure is equal to the sum of 28.28 and the first correction 0.02, which is equal to 28.30. The second is the difference between 12.50 and the second correction 0.01, making 12.49; and so is for the others, taking the sum when the departure is in the column whose sum is the least (which, in the present case, is the east), and the difference when in the other column. In the traverse table thus corrected, the sum of the differences of latitude is 57.47 in both columns, and the sum of the departures 42.08. Having corrected the values of this traverse table, you must find the meridian distances, the column M, the north and south areas, &c., as in the former example.

In projecting a survey of this kind, where there is a small error, you must plot off as usual the boundary lines AB, BC, CD, &c., and it will be found that the termination of the last line AE will not fall exactly in the point A, but will be at a point near it, which we shall call *a*. To correct this error, you must draw through the points B, C, D, &c., lines parallel to *a*A, in the direction from *a* to A, of such lengths as to be to A*a*, as the distances of those points respectively from A (measured on the boundary ABCD, &c.) are to the whole length of the boundary line; through these points draw the corrected lines terminating on A.

The Manner of Surveying Coasts and Harbors.

From what has been said in the preceding problems, the intelligent reader will readily perceive the method of surveying a coast or harbor. But as this is an important subject, we shall enter more fully into an explanation of the different methods which may be used.

To take a draught of a coast in sailing along shore.

Having brought the ship to a convenient place, from which the principal points of the coast or bay may be seen, either cast anchor, if it is convenient, or lie-to as steady as possible; or, if the coast is too shoal, let the observations and measures be taken in a boat. Then, while the vessel is stationary, take, with an azimuth compass, the bearings, in degrees, of such points of the coast as form the most material projections or hollows.* Write down these bearings, and make a rough sketch of the coast, observing carefully to mark the points, whose bearings are taken, with letters or numbers, for the sake of reference.

Then let the ship or boat run in a direct line (which must be very carefully measured by the log, or otherwise) one, two, or three miles, until she comes to another situation, from which the same points, before observed, can be seen again with quite different bearings. Then let the vessel lie steady, as at the former station, and observe again the bearings of the same points, and make a rough sketch of the coast. This sketch may be made more accurately while the vessel is running the base line.

To describe the chart from these observations, you must, in some convenient part of a sheet of paper, draw the magnetic meridian, and lay off the several bearings taken at the first station, marking them with their proper letters or numbers. Lay down also the bearings taken from the second station. Draw a line to represent the ship's run both in length and course, and from that end of the line expressing the first station, draw lines parallel to the respective bearings taken from that end; also from the other end draw lines parallel to the bearings taken at that end, and note the intersection of each pair of lines directed to the same point; and through these intersections draw by hand a curved line, observing to wave it in and out as near as can be like the trending of the coast itself. Then mark off the variation of the compass from the north end of the magnetic meridian, towards the right hand if it be west, or towards the left hand if it be east, and draw the true meridian through that point and the centre of the circle.

* In taking the bearings, if the vessel has much motion, the mean of several observations should be taken.

Digitized by Google

Against each part draw the appearance of the land marked in the sketches, distinguishing the rocky shore, highland, beach, &c., as in Plate V. or VIII. Thus the sand beaches may be marked as in Plate VIII. figure 8, and the rocky shore as in figure 9, &c. Put in the several soundings, at low water,* in small figures, distinguishing whether they are fathoms or feet. Show the time of high water, on the full and change days, by Roman figures, and note the rise of the tide in feet. The direction and velocity of the flood tide are to be observed; which may be done by heaving the log when the ship or boat is at anchor, and the direction is to be represented by an arrow. Insert a compass and a scale of miles or leagues, such as the vessel's run was laid down by. Add the name of the place, and the latitude and longitude, as true as can be obtained.

If there are shoals or sands on the coast, let them be observed in a boat, sailing round them, keeping account of the courses, distances, and soundings.† But to put them in the draught, the observer in the boat must take the bearings of two points on the coasts (the bearings of which have been taken from the ship) from some part of each sand or shoal so sailed round; or the bearing of the boat at some part of the shoal, or of some beacon in that place, must be taken by the ship at each of the stations where the bearings of the shore were taken from the ship; for by either of these means, one point of the sand being obtained, the rest of it can be laid down from the observations taken in the boat. Rocky shoals may be marked on the chart as in Plate VIII. figure 11, and sand-banks as in figure 10.

If the coast be a bay or harbor, winding in such manner that all its parts cannot be seen at two stations, let as many bases or lines be run and measured exactly as may be found necessary, observing that the several distances run should join to one another, in the nature of a traverse, that each new set of objects or points observed should be taken from two stations at the ends of a known distance, and that the objects whose bearings are taken do not so much extend beyond the limits of the base as to make angles with it less than about ¼ or ⅓ of a point, but rather reserve such objects for the next measured base line; for when lines lie very obliquely to one another, their intersections are not easily ascertained.

If any particular parts of the harbor cannot be conveniently seen from either of the stations, take the boat into those places; having well examined them, and made sketches thereof, estimating the lengths and breadths of the several inlets, either by the rowing or sailing of the boat, take as many bearings, soundings, and other notes, as may be thought necessary; then annex these particular views in their proper places, in the general draught.

If there are any dangerous sands or rocks, besides inserting them in their proper places, you must see if there be any two objects ashore (such as a church, mill, house, noted cliff, &c.) which appear in the same right line when on the shoal, and these objects must be noted on your chart. If none can be found, you must take the bearings of some remarkable points, and note them on your chart. By this means we may know how to avoid the danger.

We must mark in the draught the kind of bottom obtained in sounding, whether mud, sand, shells, coral, rocky ground, &c.; and where there is good anchorage, draw the figure of an anchor; also, if there is any particular channel more convenient than another, it is to be pointed out by lines drawn to its entrance from two or more noted marks ashore.

The positions of objects, taken by a magnetic compass, being liable to great uncertainties, as is well known to those who have had any experience, especially at sea, it has been recommended to observe only the bearings of the station-lines by the compass, and then measure the angles which the other objects make with these lines by a quadrant or sextant, which, for this purpose, must be held in a horizontal position.

EXAMPLE I. (See Plate VII. fig. 1.)

Suppose, in a ship at A, we observe the bearings of the most remarkable points of a bay, C, D, E, F, G, H, and I, and then sail S. 64° E. 1¼ miles to B, and at B observe the bearings of the same points; it is required to construct the chart.

---

* If the soundings were not taken at low water, they may be reduced thereto by a method which will be explained hereafter.

† It is difficult to ascertain correctly the courses and distances sailed by the boat, on account of the currents and other causes. This inconvenience may be obviated, if the ship be at anchor, and not far from the boat, by observing in the boat the bearing of the ship by compass, and by measuring, with a quadrant, the angle contained between the top-gallant-mast head and that part of the ship which is at the same height as the eye of the observer; for by this angle the distance of the boat from the ship may be determined, as will be explained hereafter.

Digitized by Google

Bearing of	C from A,	S. 36° W.	Bearing of	C from B	S. 89° W.
	D	N. 9° W.		D	N. 48° W.
	E	N. 26° E.		E	N. 24° W.
	F	N. 55° E.		F	N 13° E.
	G	East.		G	N. 47° E.
	H	S. 40° E.		H	S. 38° W.
	I	S. 19° E.		I	S. 46° W.

Draw the line AB, S. 64° E. 1½ miles. Through the points A and B draw the lines AC, AD, AE, AF, AG, AH, AI, BC, BD, BE, BF, BG, BH, and BI, with their respective bearings; and where the corresponding lines cut each other, will be the points C, D, E, F, G, H, and I, respectively. Through these points the different curvatures of the land must be drawn, corresponding with your eye-draught. In this manner may a chart be constructed by observations taken upon the water. The manner of surveying upon land is exactly similar.

To survey a harbor by observations on shore.

Make an eye-draught of the place to be surveyed, and, in going round the coast, fix station-staves, or straight poles, tall enough to be seen at a considerable distance, in the most remarkable points and bendings of the shore; but if at any of those places there is a noted tree, house, or any other remarkable thing, that object may serve instead of a station-staff; and it will be convenient to black the staves, and tie a piece of white bunting at the top of each; then in the eye-draught put letters or numbers, at the noted points or marks, for the sake of distinction.

Choose the most extensive and level spot of ground you can meet with to measure your base line upon. This line must not be less in length than a tenth part of the distance of the two extreme objects which are to be observed; and the two extreme points of it must be so situated that as many of the station-staves as possible may be seen from both of them. The bearing or position of the base must be well determined in degrees and minutes, and the length accurately measured, either by a measuring-chain or a piece of log-line.

From each end of the base observe, with an azimuth compass, or with a theodolite (if it can be procured), the bearings of each of the station-staves; or else with a sextant measure the angles contained between the staves or remarkable objects and the other end of the station-line, and write them down, in regular order, in your book. These measures and angles, being plotted down, as before directed, will give the most conspicuous points of the shore. The intermediate spaces are to be filled up from the sketches made on the spot.

But if any one of these objects be situated so far beyond the limits of the base as to appear nearly in the same direction, or to make angles not exceeding 10°; or if some of the remarkable objects be visible only from one end of the base; then let the bearings of such objects be taken from a place whose position has been determined from both ends of the measured base: or, if there are several remarked objects which cannot be seen from either end of the base lines, let the bearings of such objects be taken from each of two points whose positions have been determined by bearings taken from both ends of the base: or it may, on some occasions, be proper to choose another place on which another base, of a convenient length, may be measured, and from the extremities of which the ends of the first base may be seen, and as many as possible of the remaining objects which lay too obliquely, or which could not be seen from the first base. In such manner proceed until the bearings are taken of all the points judged necessary for completing the survey of the limits of the harbor.

If a right line of a sufficient length for a base line cannot be measured, it may be taken in two adjoining lines, as the two sides of a triangle, the included angle being accurately measured, and the bearing of one of the lines observed.

When the outlines or limits of a harbor, bay, road, &c., are delineated by the preceding precepts, let a small vessel go out to sea to take drawings of the appearance of the land and its bearings. Sail likewise into the harbor, and draw the appearance of its entrance. Take particular notice if there be any false resemblance of the entrance, by which ships may be deceived and run into danger; or if any two objects, being brought in a line, will lead into the harbor without danger. Search for the best anchoring-places, and, if possible, denote those places by bringing two objects in one; if not, take the exact bearings of two or three other objects, so that the places may be easily determined. After drawing the chart, we must insert a compass, with the variation, and scale properly fitted to the plan. Then the islands, rocks, sands, &c., must be marked in their proper places, with their soundings at low water; the

Digitized by Google

anchoring-places, with the best track to get to them; the proper sailing-marks to avoid dangers; the places where fresh water can be obtained; the name of the place, that of the country, or of the sea; the latitude and longitude; a sketch of the appearance the place makes at sea, upon a known bearing, and at an estimated distance; and whatever else a judicious seaman may think proper to insert. Then will the plan be fit for all nautical purposes, and may be embellished with proper colors, if necessary

EXAMPLE II. (See Plate VII. fig. 2.)

From each end of a base line AB of 1200 fathoms, were observed the points C, D, E, F, and G; and as the points I, K, and L, were not visible from the extremities of the base line, another base line was measured, from the point D to H, of 680 fathoms, from which points the bearings of I, K, and L, were observed. Hence it is required to construct a chart of the place.

Bearing of B from A,	East.	Bearing of C from B,	N. W. b. W.
C	North.	D	N. N. W.
D	N. E. b. N.	E	North.
E	N. E. ½ N.	F	N. b. E.
F	N. E. b. E. ½ E.	G	N. E.
G	E. b. N. ½ N.		
Bearing of H from D,	N. W.	Bearing of I from H,	N. E. b. N.
I	N. b. W.	K	N. E. ½ E.
K	N. b. E. ½ E.	L	E. N. E.
L	N N. E. ½ E.		

Draw the east line AB equal to 1200 fathoms; from each end of this line draw the lines AC, AD, AE, AF, AG, BC, &c., at their respective bearings; the points of intersection will give the points C, D, E, F, and G. From the point D (which was found in this manner) draw the N. W. line DH equal to 680 fathoms, and through these points draw the lines DI, DK, DL, HI, &c., at their respective bearings; the points of intersection of the corresponding lines will be the situation of the points I, K, L. Between these remarkable points, draw the outlines of the land, conformable to your rough draught.

In order to determine the situation of the point M, which was seen too obliquely from the bases AB, DH, you may take the bearing of that point from B, and then from G (whose situation has been determined by bearings taken from the points A, B); the intersection of the lines BM, GM, will determine the situation of M.

Method of surveying a small bank or shoal where great accuracy is required.

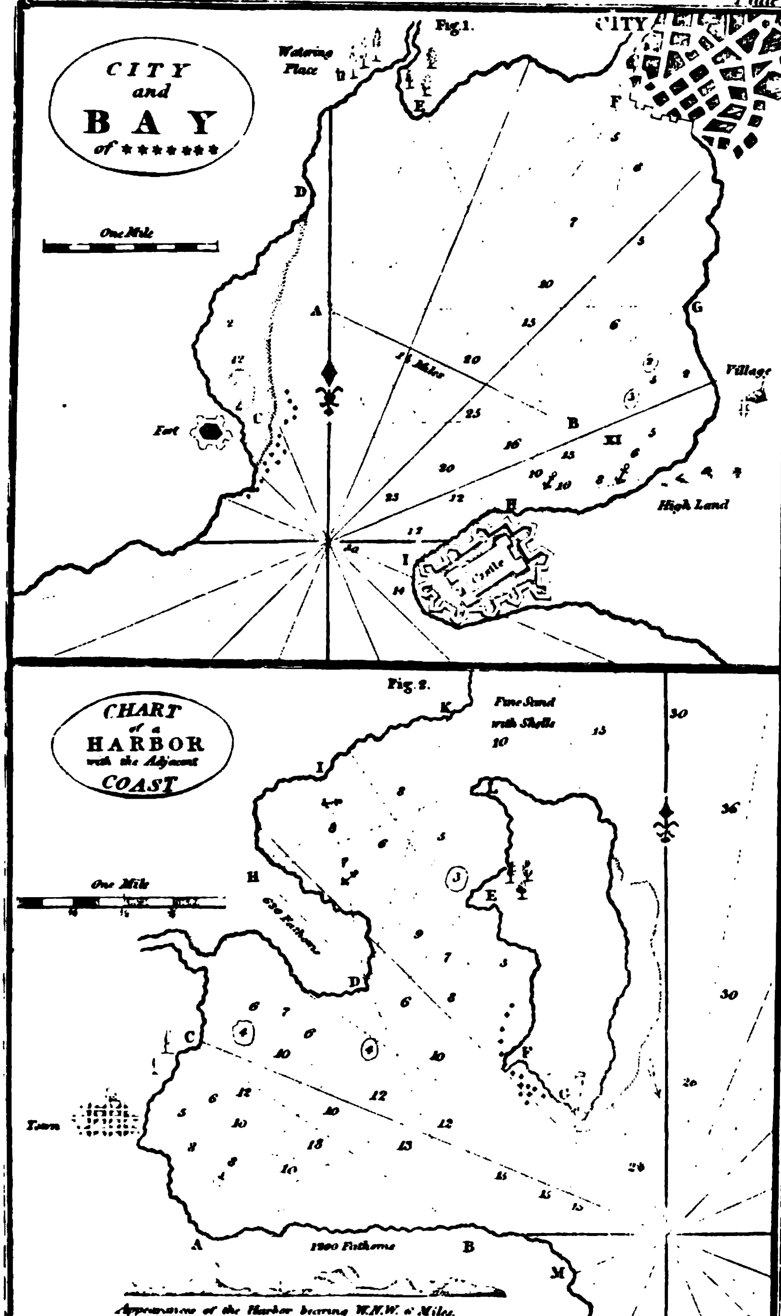
The method of determining the extent and situation of shoal ground by sailing round it, and keeping an account of the courses and distances sailed, is well adapted to the taking of an extensive survey, or to the exploring of a large bank, where great accuracy is not required. But the difficulty of ascertaining with precision the courses and distances sailed (which are liable to error on account of the tides, currents, and the different velocity of the boat at different times, owing to the unsteadiness of the wind) prevents this method from being sufficiently accurate to be used in exploring a dangerous shoal or bank at the entrance of a narrow channel of a harbor, or any other place where the exact form of the shoal is to be found; and if to obtain the necessary degree of correctness, the bearings of two remarkable objects are taken at every time of sounding, the time expended in taking the observations, if there be only one observer, will be increased beyond all reasonable bounds. To obviate these difficulties, we may use either of the following methods, by which the necessary observations for determining the situation of the boat, can be made as fast as the soundings are taken.

First Method. Procure a large sail-boat with a high mast, and a small row-boat. Bring the sail-boat to anchor on the bank which is to be explored, and take accurately the bearings of two remarkable points of land, or other objects, whose situation has already been determined by observations taken on shore, or in sailing along the land. By this means the situation of the sail-boat may be accurately marked on the chart. Then enter the small boat, and row from the other in any particular direction, observing to keep the mast of the boat to bear upon any point of the compass, or (which is much more accurate) to keep the mast of the boat to range on any particular point of land,

Digitized by Google

SURVEYING.

Plate VII.



Digitized by Google

Digitized by Google

or other object marked on the chart, so that any error which might arise in the course of the boat may be prevented. While proceeding in this direction, let one person take the soundings, while another observes, with a quadrant or sextant, the angular elevation of the top of the boat's mast above the horizontal line drawn from the eye of the observer, and a third person notes the observations in the minute-book, and the time of observation, in order to make the necessary reduction in the soundings, to reduce them to low water. Proceed in this manner from the sail-boat, till you get off the bank into deep water, or till the elevation of the mast is not much less than one degree; then row across the bank till the bearing of the mast is altered considerably or till it appears in a range with another point of land, at a considerable angular distance from the point with which the mast ranged in the first observations; then row towards the boat, sounding and observing the angular elevation of the mast as before. Proceed in this manner, in sounding to and from the sail-boat, till you have procured a sufficient number of soundings in every direction. Then go on board the sail-boat, and shift her birth to another part of the bank, where soundings have not been taken, and proceed to sound as before. Continue sounding and shifting the situation of the boat, till the whole bank has been explored, and then the observations may be plotted off by the directions in the following example.

Let ABC (Plate VIII. fig. 1) be the mast of the sail-boat; D the situation of the eye of the person who observes the angular elevation of the mast. Draw the line BD parallel to the horizon, and join AD. Then the height AB must be measured* accurately, and, that being given and the observed angle ADB, the corresponding distance BD may be obtained by the usual rules of trigonometry, by saying, As radius : AB :: cotangent ADB : BD. Thus, if the height AB be 30 feet, and the angle ADB 1°, the distance BD will be 1719 feet (being 57.3 times as great as AB). The distances corresponding to 2°, 3°, &c., are given in the adjoined table, by examining which it will appear that the distance BD corresponding to any angle ADB (less than 30°) may be obtained nearly by dividing 1719 by the angle ADB in degrees. Thus, for 4 degrees, by this rule, the distance would be $\frac{1719}{4} = 429\frac{3}{4}$ nearly, as in the table. The greatest difference between the distances determined by the rule and by the table is 5 feet, corresponding to the angle 30°: for $\frac{1719}{30} = 57$, whereas by the table the distance is 52. In taking soundings by this method, it will be very rarely necessary to measure an angle so great as 30°; so that, for all practical purposes, the distance may be determined, in this example, to a sufficient degree of accuracy, by dividing 1719 by the observed angular elevation in degrees. On these principles we have the following rule for calculating the distance, corresponding to a mast of any given height, and to any observed angular elevation.

ADB	BD
	FEET.
1°	1719
2	859
3	572
4	429
5	343
10	170
20	82
30	52

RULE. *Multiply the height of the mast above the eye of the observer by 57.3, and the product will be a constant quantity,† which, being divided by the observed angle of elevation, expressed in degrees and decimals of a degree, the quotient will be the sought distance nearly.*

If the height of the mast be expressed in equal parts, taken from the scale by which the chart is plotted off, the distances found by the above rule will be expressed in the same equal parts; so that, if the distances thus expressed, corresponding to 1°, 2°, 3°, &c., be calculated and marked on a slip of paper (Plate VIII. fig. 2) from H to 1°, from H to 2°, and from H to 3°, &c., respectively, the slip H 1, thus marked, will be a very convenient scale for plotting off such distances.

For further illustration of this method, we have given an example in Plate VIII. fig. 4, in which C represents the place where the sail-boat is at anchor; A and B the

* A mark may be made at B, and a vane placed at the top of the mast at A, to enable the observer to distinguish those objects when at a great distance. If the height of the observer above the horizon be small in comparison with the height of the mast, the angular distance ADE between the surface of the sea, near the boat, and the top of the boat's mast may be measured, instead of ADB; for, if the distances BC and CE remain the same in all observations, it will be immaterial which angle is measured; observing, however, that different scales must be used for plotting off the angles ADB and ADE.

If AB represent the known vertical height of the summit of an island above the eye of an observer, the distance from the island can be determined by measuring the angular elevation ADB, as is evident from what has been said above.

† This constant quantity may be determined without actually measuring the altitude AB, if the angular elevation can be measured at a place D, where the distance BD is known. Thus, in the example (Plate VIII. fig. 4), the distance AC being known, and the angular elevation of the mast at C being observed at A in degrees and decimals of a degree, and multiplied by the distance AC, the product will be the constant quantity mentioned in the rule. This method may be used in determining the distance from an island by the method mentioned in the last note.

Digitized by Google

points observed, in order to ascertain the position of the boat on the chart, by drawing thereon the lines AC, BC, in opposite directions to the bearings of the points A, B observed from the boat,—the point of intersection C being evidently the place of the boat upon the chart. Suppose, now, that in the first set of observations, the mast of the sail-boat is made to range on the point A; in this case the course of the boat must be on the continuation of the line AC towards D: then the slip H I (Plate VIII. fig. 2) is to be laid upon the line CD (Plate VIII. fig. 4), with the point H upon C; and the angular elevation being found on the slip, the sounding corresponding (reduced to low water) is to be marked on the line CD, immediately under the mark on the slip. Thus, if the angle be 4°, the point corresponding will be G. Having plotted off the soundings taken in the direction CD, proceed in the same manner with the others, viz. those in the direction CE, found by keeping the boat's mast in a range with the church at H; those in the direction CF, found by keeping the boat's mast in a range with the point B; those in the direction CA, found by keeping the mast to bear E. N. E.; and so on with the other observations. When all the soundings are marked on the chart, dotted lines are to be made round the shoal soundings; and thus the true figure of the shoal part of the bank will be obtained.

This method I have frequently used in taking a survey of the part of the coast of Massachusetts Bay included between Manchester and Lynn. The height of the mast of the boat used on the occasion was about 30 feet; and it was found that distances less than a third of a mile could be obtained in this manner to a great degree of precision.

Second Method. This method of determining the place where soundings are taken, consists in keeping (while sailing in a boat and sounding) a particular point of land, or any other object, to bear always in the same direction, and measuring with a quadrant or sextant, held in a horizontal position, the angular distance between that object and another object making a considerable angle with the former; for by this means the situation of the boat at the time of sounding may be determined. Instead of bringing the object to bear upon a particular point of the compass, you may (when it can be done) bring the object in a range with another remarkable object, and by this means you will avoid the error which might arise from the use of a compass.

For an example of this method, suppose that a survey of the small islands A B, K (Plate VIII. fig. 3), and the large one CGH, has been taken and plotted off as in the figure. Then soundings may be taken, in the direction BCD, by bringing the small island B in a range with the southern part of the great island, and measuring the angle CDG formed by the extremes of the great island; or by keeping the small island A to range with the northern part of the great island, and measuring the angle HIK formed by the northern extreme of that island and the small island K; or by running in the direction KL, so as to keep the island K to bear W. ¼ S., and measuring the angle formed by that island and the northern extreme of the great island, &c.

The method I have generally used for plotting off such angles, is by means of a sector; and as that instrument is more easily procured than others better adapted to the purpose, I shall explain the method by showing how the angle CDG, measured as above, may be plotted off so as to determine the point D where that angular distance was observed. To do this, you must draw the line CD, and open the sector till the two legs form with each other an angle equal to the observed angle CDG; then slide one leg of the sector on the line CD till the other leg touches the northern extreme of the island at the point G, and the point directly under the centre of the joint of the sector will be the point of observation. As this point cannot be exactly marked, on account of the size of the joint of the instrument, you may mark with a pencil on the line CD the two points where the circumference of the joint touches that line, and note the sounding in the middle between those two marks.

If a quadrant of a circle be described on a piece of paper, with a radius equal in length to one of the legs of the sector, and then divided into 90°, the sector may, by means of that quadrant, be opened to any angle in a very expeditious manner.

This method of obtaining distances when sounding, I have frequently used with success.

Third Method—with two observers. This method is founded upon the process explained in Problem VII. page 93. It consists in finding, at the same time, by means of two observers furnished with sextants, the horizontal angles ADC, BDC, (figure Problem VII. page 93) formed, at the point D of the shoal, by the right lines DA, DC. DB, drawn to three points of land or remarkable objects, A, C, B whose positions are given on the chart, or have been ascertained by previous observations. In this way various points D of the shoal or bank may be found, while the boat is sailing over it;

Digitized by Google

and the corresponding soundings can, at the same time, be observed. As the process of projecting and computing such observations has already been explained in Problem VII., it will not be necessary to make any additional remarks in this place, except that great care must be taken in selecting the points to be observed, A, C, B, so as not to have the centres, F, G, of the two intersecting circles, ABD, BCD, near to each other; because, in that case, a slight error in either of the observed angles, ADC, BDC, may produce a very important error in the situation of the point D of the shoal, corresponding to the intersection of these circles; it being evident that the method would wholly fail if the point C were to be placed at E upon the circumference of the circle ABD, because the centres F, G, would then coincide, and there would be no single point of intersection D, since any point whatever of the circumference of the circle BCD would satisfy the observations. This difficulty is inherent in this method of observation, and no process of numerical calculation will help it; so that we may rest assured, that whenever it is difficult to find the precise point of intersection D, by a geometrical construction, the points A, C, B, have not been well selected; and the observations may lead to a very incorrect result, except the angles are taken with the utmost degree of accuracy.

To reduce soundings taken at any time of the tide to low water.

The soundings at low water are always to be marked on a chart; and if they are taken at any other time of the tide, a correction must be applied to reduce them to low water. This allowance may be made, if the whole vertical rise of the tide from low to high water be known, with the time of high and low water, as in the following example:—

Suppose the vertical rise of the tide, from low to high water, to be 10 feet, the time of low water 5h. A. M., and the time of high water 11h. 30m. A. M.; required the allowance to be made on an observation taken at 8, A. M.

Draw the line AC (Plate VIII. fig. 5), and make it equal to the whole rise of the tide, 10 feet, taken from any scale of equal parts, and divide the line into equal parts, representing feet, at the points 1, 2, 3, &c. to 10, the mark 10 (corresponding to the whole rise of the tide) being at the point C; and through these points draw lines 11, 22, 33, &c., perpendicular to AC, to meet the circumference of a circle drawn on the diameter AC. Divide the semicircumference ABC of this circle into a number of equal parts representing the number of hours elapsed from low to high water * (which, in this case, is 6½h.), the hour of low water being marked at A, and that of high water at C, the intermediate hours being marked in succession, as in the figure; then, any hour being found on the arc, the number of the line drawn perpendicular to AC, and passing through the hour, will represent nearly the number of feet to be subtracted from a sounding taken at that time, to reduce it to low water. Thus the number of feet corresponding to 8h. is between 4 and 5, because the mark 8h. falls between the lines marked 4 and 5; therefore the reduction is between 4 and 5 feet, on soundings taken at 8, A. M., to reduce them to low water, on the day of observation and if, on that day, the tide does not ebb so much as on a spring tide, the reduction must be increased by the difference in the ebbing of the two tides. Thus, if, on the day of observation, the tide did not ebb so much by two feet as on a spring tide, the reduction corresponding to 8h. must be increased two feet, and will therefore be between 6 and 7 feet. Allowance may be made for this, by increasing the number of feet given in figure 5, by marking 2 feet at A, 3 feet at 1, 4 feet at 2, &c., as is evident.

To reduce a draught to a smaller scale

With a black-lead pencil, draw, on the draught to be reduced, cross lines, forming exact squares; and on the clean paper for the copy draw the same number of squares, making their sides larger or smaller in proportion to the intended size of the scale, such as ½, ¼, &c., the length of the other. Distinguish by a stronger mark every fifth or sixth row of squares in both, so that the several corresponding squares may be readily perceived; then, in each of the squares of the draught, draw, by the eye, a curve on the paper, similar to that in the square of the copying-draught, till the whole is copied, when the black-lead lines may be rubbed out with bread or India-rubber.

---

* This division of the semicircle may be made by means of a line of chords; the number of degrees corresponding to one hour being found by saying, As the whole elapsed time from low to high water (6½ hours) is to 180°, so is one hour to the arc corresponding to 1 hour, 27° 42′, which, being taken from a line of chords, and laid off from 5h., will reach to 6h., &c.

Digitized by Google

A chart may also be reduced in the following manner, thus :— Suppose you would reduce a chart in the ratio of the line MN (Plate VIII. fig. 6) to HI. Draw the line AC, and make it equal to HI; upon A, as a centre, describe the arc CF, and make the chord CF equal to MN; join AF; then, if you take any distance, AB, you wish to reduce, ~~and, upon A as a centre, describe an arc BD, the chord BD, intercepted~~ by the lines AC, AF, will be the reduced distance corresponding to AB. This reduced distance may also be obtained by another method, which is more simple than the former:—Take any extent from the large chart, which is to be reduced to a smaller scale, and apply it from A to O (Plate VIII. fig. 7); take in your compasses the corresponding distance on the small chart, and, with one foot in O, sweep an arc P; draw the line AP just touching the arc in P; then, if you take any distance from the great chart, and apply it from A to R, and, at the point R, sweep an arc S to touch the line AP, the extent RS will be the reduced distance corresponding to the line AR.

Comparison of the French BRASSE *with the English* FATHOM.

Brasses.	Fathoms.	Brasses.	Fathoms.
1	0.9	9	8.0
2	1.8	10	8.9
3	2.7	20	17.8
4	3.6	30	26.6
5	4.4	40	35.5
6	5.3	50	44.4
7	6.2	75	66.6
8	7.1	100	88.8

Comparison of the Spanish BRAZA *with the English* FATHOM.

Brazos.	Fathoms.	Brazos.	Fathoms.
1	0.9	9	8.3
2	1.9	10	9.3
3	2.8	20	18.5
4	3.7	30	27.8
5	4.6	40	37.1
6	5.6	50	46.4
7	6.5	75	69.5
8	7.4	100	92.7

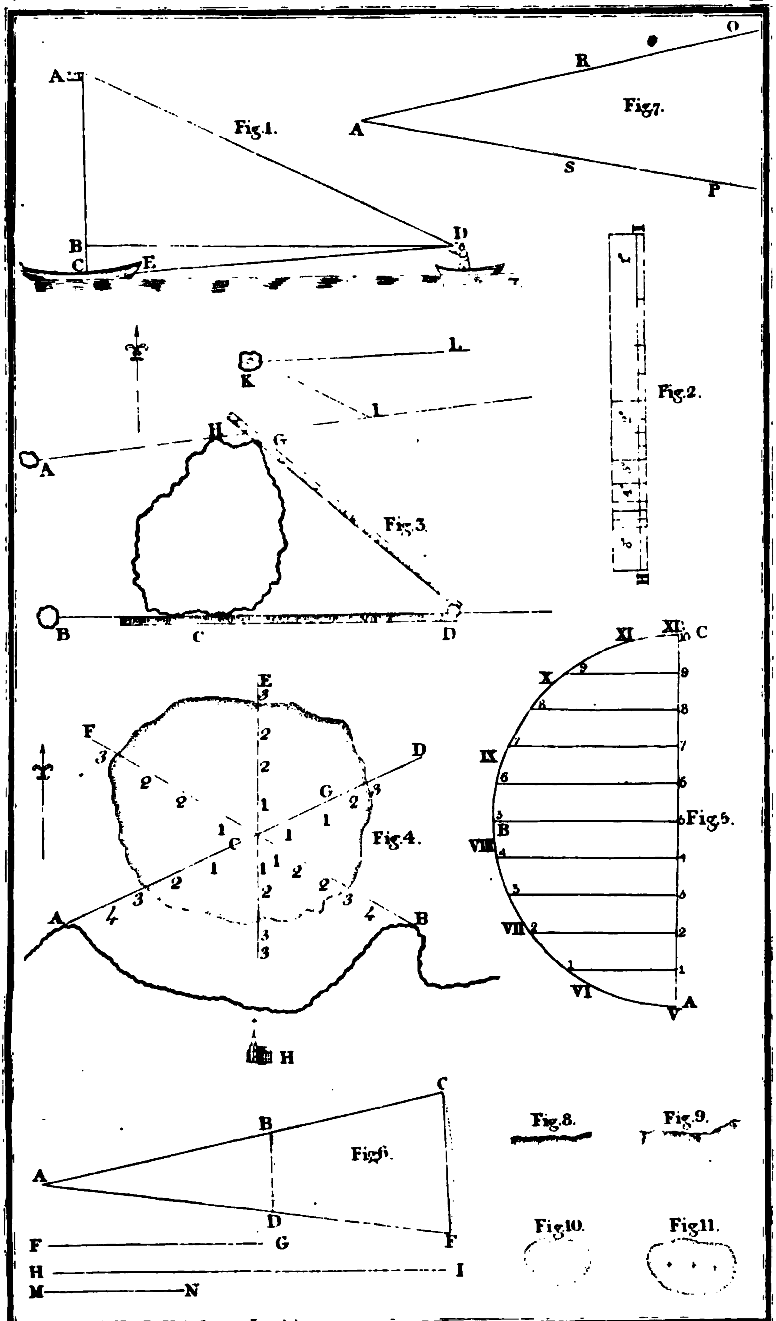
Comparison of the Russian SASHE *with the English* FATHOM.

Sashes.	Fathoms.	Sashes.	Fathoms.
1	1.2	9	10.5
2	2.3	10	11.7
3	3.5	20	23.3
4	4.7	30	35.0
5	5.8	40	46.7
6	7.0	50	58.3
7	8.2	75	87.5
8	9.3	100	116.7

Comparison of the Dutch PALM *with the English* FATHOM.

Palms.	Fathoms.	Palms.	Fathoms.
1	0.055	9	0.492
2	0.109	10	0.547
3	0.164	20	1.094
4	0.219	30	1.641
5	0.274	40	2.188
6	0.328	50	2.735
7	0.383	75	4.103
8	0.438	100	5.470

Digitized by Google



Digitized by Google

OF WINDS.

The earth is surrounded by a fine, invisible fluid, called *air*, which, by its weight, is capable of supporting the vapors raised by the sun, and, by its elasticity, is capable of expanding or spreading itself so as to fill up a larger space. When the elasticity of any portion of the air is changed, by the heat of the sun or by other causes, the neighboring parts are put in motion to restore the equilibrium. In this manner a current of air is formed, called the *Wind*, which is distinguished by several names, viz. *trade winds*, *monsoons*, *variable winds*, &c. The *trade winds* blow constantly from the same part; the *monsoons* blow half the year one way, and half the other; and the *variable winds* are such as blow without any regularity either as to time, place, or direction. The following observations on the wind have been made by Dr. Halley and others.

There are constant trade winds, blowing from the east, in most parts of the Atlantic and Pacific Oceans, between the latitudes of 30° N. and 30° S. Near the northern limits of these winds, they blow between the north and east; and near their southern limits, between the south and east.

In the Atlantic Ocean, at about 100 leagues from the coast of Africa, between the latitudes of 28° and 10° north, there is generally a fresh gale of wind blowing from the N. E.

Those bound to the Caribbee Islands, across the Atlantic, find, as they approach the American side, that the N. E. wind becomes easterly, or seldom blows more than a point from the east, either to the northward or southward.

These trade winds, on the American side, are sometimes extended to 30°, 31°, or even to 32° of north latitude, which is about 4° farther than what they extend to on the African side; also to the southward of the equator, the trade winds extend 3 or 4 degrees farther towards the south, on the coast of Brazil, on the American side, than they do towards the Cape of Good Hope, on the African side.

But we must not conclude that the above limits are without exception; for both their extent and direction vary considerably with the season of the year. When the sun approaches the tropic of cancer, the S. E. trade winds prevail further to the northward of the line, and incline more to the southward of S. E; and the N. E trade wind inclines more to the eastward; and the contrary at the opposite season of the year.

On the African coast, from Cape Blanco to Sierra Leone, the winds in general blow from the north, inclining from the westward rather than from the eastward. From Sierra Leone to Cape Palmas, the ordinary course of the winds is from W. N. W., and beyond Cape Palmas, as far as 28° south latitude, from S. W. to S., inclining more to the southward or westward, according to the particular situation or bearing of the shores and lands; and the part of the ocean extending along this coast, to the distance of 80 or 100 leagues from the shore, is much troubled with frequent calms, and with sudden and violent gusts of wind, known by the name of *tornadoes*, which blow from all parts of the horizon The reason of this change in the direction of the trade wind near the land, is probably owing to the nature of the coast, which, being violently heated by the sun, rarefies the air exceedingly; consequently the cool air from the sea will keep rushing in to restore the equilibrium.

In the Gulf of Guinea, there is a periodical wind, called *harmattan*, which blows in a N. E. direction from the interior parts of Africa. The season in which this wind prevails, is during the months of December, January, and February.

Between the 4th and 10th degrees of north latitude, and between the longitude of Cape Verd and the easternmost of the Cape Verd Islands, there is a tract of sea which seems to be very liable to calms, attended with much thunder and lightning, and frequent rains. The cause of this seems to be, that the westerly winds, setting in on the coast of Africa, and meeting the general easterly winds in this tract, balance each other, and so cause the calms; and the vapors, carried thither by each wind, meeting and condensing, occasion the almost constant rains.

These observations show the reason of the difficulty which ships find in sailing to

Digitized by Google

the southward, between the coasts of Guinea and Brazil, particularly in the months of July and August, notwithstanding the width of the sea is more than 500 leagues; for the S. E. winds, at that time of the year, commonly extend some degrees beyond their ordinary limits of 4° north latitude, and become more southerly, so as to be sometimes south, or a point or two to the west of south. It then only remains to ply to windward; and if, on the one side, they steer W. S. W., they get a wind more and more easterly; but then there is danger of falling in with the coast or shoals of Brazil; and if they steer E. S. E. they fall into the neighborhood of the coast of Guinea, whence they cannot depart without running easterly as far as the island of St Thomas.

When ships depart from Guinea for Europe, their direct course is northward; but on this course they cannot go, because, the coast trending nearly east and west, the land is to the northward. Therefore, as the winds on this coast are generally between the south and W. S. W., they are obliged to steer S. S. E. or south, and with these courses they run off the shore; but, in so doing, they always find the wind more and more contrary, so that though, when near the shore, they can lie south, at a great distance they can make no better than S. E., and afterwards E. S. E., with which courses they generally fetch the island of St. Thomas or Cape Lopez, where finding the wind to the eastward of the south, they sail westerly with it, till, coming to the latitude of 4 degrees south, they find the S. E. wind blowing perpetually.

On account of these general winds, all bound from Europe to the West Indies, or to the southern States of America, consider it most advantageous to get as soon as they can to the southward, so they may be certain of a fair and fresh gale, to run before it to the westward. For the same reason, those bound from the southern States of America to Europe endeavor to gain the latitude of 30 degrees, where they first find the wind begin to be variable, though the most ordinary winds in the North Atlantic Ocean come between the south and west.

And, for the same reasons, those bound to India from America run to the eastward in the variable winds, so as to be in the longitude of 35° or 38° W. when in the latitude of 30° N. From thence they steer south-easterly towards the Cape de Verds, passing 4° or 5° to the westward of them, unless they wish to stop for supplies. Being then in the common route of the European Indiamen, they steer southerly to cross the equator between the longitude of 20° W. and 28° W., where, meeting the S. E. trade winds, they must brace up and sail upon a wind till they get through them and come into the variable winds, where they may steer to the eastward. Near the equator, the trade wind is generally stronger to the westward than to the eastward; and were it not for the fear of falling in with the Brazil coast, a ship might cross the line even farther to the westward. Ships homeward bound, from the Cape of Good Hope towards America, may deviate a little to the westward of their straight course, and cross the equator in the longitude of 30° W., or even as far as 33° W., in order to take advantage of this fresher trade wind.

Between the southern latitudes of 10° and 30° in the Indian Ocean, the general trade winds about S. E. are found to blow, all the year round, in the same manner as in the like latitudes in the South Atlantic Ocean; and during the six months from May to November, these winds reach to within 2 degrees of the equator; but during the other six months, from November to May, a N. W. wind, called *the little monsoon*, blows in the tract lying between the 3d and 10th degrees of south latitude, in the meridian of the north end of Madagascar, and between the 2d and 12th degrees of south latitude, near the longitude of Sumatra and Java.

In the tract between Sumatra and the African coast, and from 3° of south latitude quite northward to the Asiatic coast, including the Arabian Sea and the Bay of Bengal, the monsoons blow from October to April on the N. E., and from April to October on the S. W. In the former half-year, the wind is more steady and gentle, and the weather clearer, than in the latter six months. In the Red Sea, the winds blow nearly nine months of the year from the southward, that is, from August to May, and the rest of the year from the N. and N. N. W. with land and sea breezes. In the Gulf of Persia, from October to July, the winds blow from the N. W., and about three months from the opposite quarter; these winds being often interrupted by gales from the S. W., and by land breezes.

Between the island of Madagascar and the coast of Africa, and thence northward as far as the equator, there is a tract wherein, from April to October, there is generally a S. S. W. wind, and a contrary wind the rest of the year, with regular land and sea breezes on both coasts.

To the eastward of Sumatra and Malacca, on the north of the equator, and along the coasts of Cambodia and China, quite through the Philippines as far as Japan, the monsoons blow N. E. and S. W., the N. E. setting in about October or November and the S. W. about May

Digitized by Google

Between Sumatra and Java to the west, and New Guinea to the east, there are regular monsoons. The N. W. monsoon blows from October to April; the S. E monsoon the rest of the year.

The monsoons do not shift suddenly from one point of the compass to the opposite. In some places the time of the change is attended with calms, in others by variable winds; and it often happens, on the shores of Coromandel and China, towards the end of the monsoons, that there are most violent storms called *ty-foongs*, greatly resembling the hurricanes in the West Indies, wherein the wind is so violent, that hardly any thing can resist its force; for this reason, it is more dangerous to approach these shores at the time of the breaking up of the monsoon, than at any other season of the year.

The *land* and *sea breezes* prevail principally between the tropics. The sea breeze generally sets in about ten in the forenoon, and continues till about five or six in the evening: at seven the land breeze begins, and continues till about eight in the morning. The cause of these winds is this:—During the day, the sea is not so much heated by the sun as the land, nor so much cooled at night. Hence, in the day time, the cooler air from the sea will rush towards the land, to supply the deficiency occasioned by the greater rarefaction of the air; and from this arises the sea breeze In like manner, during the night, the air at land, being more cooled than that at sea, will therefore blow from the land towards the sea, and occasion a land breeze.

A *whirlwind* is a dangerous phenomenon, caused by the adjacent air rushing in from all parts towards a centre with great rapidity, and sometimes destroying every object it passes over in its progressive motion. *Water-spouts* and whirlwinds arise from the same cause: the latter, being formed at land, are composed principally of air; but the former, being formed at sea, are composed of water.

It was first observed by Dr. Franklin, that the N. E. storms, on the coast of the United States of America, frequently begin earlier in the southern States than in the northern. This he accounts for by supposing a great rarefaction of air in or near the Gulf of Mexico; the air rising thence has its place supplied by the next more northern, and therefore denser and heavier air; a successive current is thus formed, to which the coast and inland mountains give a N. E. direction.

Experiments have been made by several persons to determine the velocity of the wind, by observing the space passed over by a cloud or any light substance, and by other methods; and it has been found that the velocity of the wind, in a violent gale, is about 50 or 60 miles per hour.

Digitized by Google

TIDES.

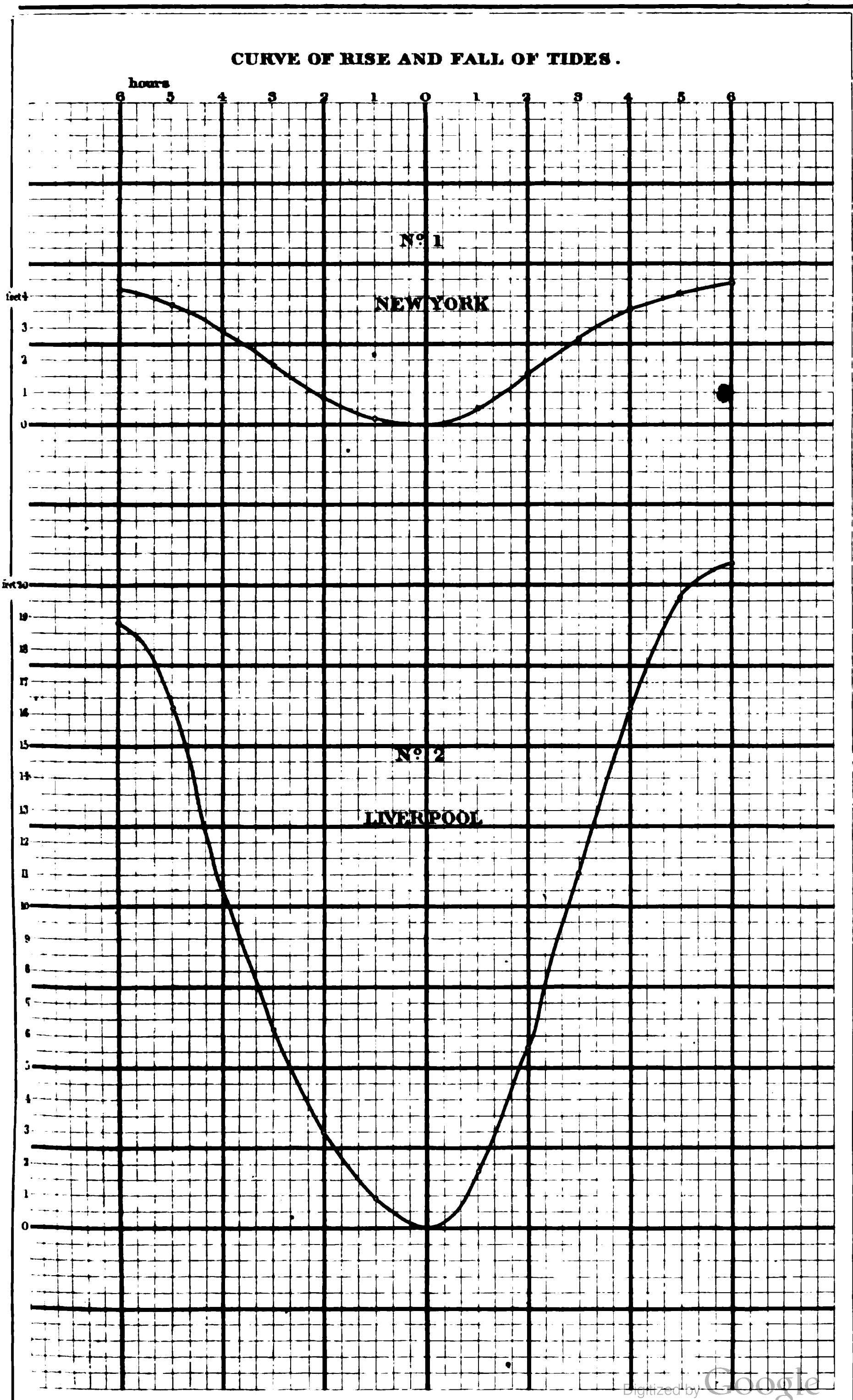
The tides are periodical changes of level of the water occurring generally twice in each lunar day. The rise of the tide is known as the flood and its fall as the ebb, the highest rise of any flood being called high tide or high water or full sea, and the lowest fall of any ebb being termed low tide or low water. Each ebb and each flood occupies about six lunar hours. The *rise and fall* of the tide is the difference of level at low and high water. These periodical changes of level known as the tides should be carefully distinguished from the effects which they produce, known as *tidal currents*. These refer to the horizontal motion of the water,

The cause of the tides is the unequal attraction of the sun and moon upon different parts of the earth; for they attract the parts of the earth's surface nearer to them with a greater force than they do its centre. and attraot the centre more than they do the opposite surface. To restore the equilibrium, the waters take a spheroidal figure, whose longer axis is directed towards the attracting body. The mean force of the sun in raising the tide is to that of the moon only as 1 to $2\frac{1}{2}$, for though the mass of the sun is vastly greater than that of the moon, its distance causes it to attract the different parts of the earth with nearly the same force. A small inland sea, such as the Mediterranean or Baltic, is little subject to tides, because the action of the sun and moon is always nearly equal at the extremities of said seas. The mathematical theory of the tides has not yet reached the point where the tides at any given place, or even the changes from tide to tide at the same place, can be calculated by merely knowing the position of the sun and moon without resort to observation. Nevertheless, by theory combined with observation, we are enabled to predict the tides within moderate limits.

High water occurs on the average of the twenty-eight days, comprising a lunar month, at about the same interval after the time of the moon's crossing (transit over) the meridian. This nearly constant interval, expressed in hours and minutes, is known as the lunitidal interval. The observed interval at the time of full and change of the moon at any port is called the establishment of the port, a word which is in common use among navigators, and the amount of which is designated on the charts by Roman numerals and fractions. Thus (vii$\frac{1}{2}$), near Sandy Hook, on a chart denotes that seven hours and a half after the moon's transit on full and change days high water will occur. The average of all the lunitidal intervals in a month which gives a more correct result, taking one day with another in the course of the month, has been termed by Mr Whewell (one of those who have recently done most for the knowledge of the tides) "*corrected establishment*," and to distinguish the other number it is called the "vulgar (or common) establishment." In our tables of establishment, the corrected ones are specially marked and are for the ports of the United States, the same with those given upon the Coast Survey charts.

The highest tides do not occur at the precise time of full and new moon, but subsequent to full and change. Upon our Atlantic coast they occur one day after, and on the Atlantic coast of Europe two days after, but on our Pacific coast nearly at full and change. The highest tides are called *spring* tides, and the lowest, occurring when the moon is near the first and third quarters, are called *neap* tides. At the periods of full and change the attraction of the sun and moon conspire to raise the tide at a given place; at the first and last quarter the high water produced by the moon would occur at the time of the low water caused by the sun, and vice versa, so that the two actions oppose each other.

By fixing a staff graduated, say, into feet and inches, against the vertical face of a pier or wharf, and observing the mark which the water reaches *at low water*, we shall see, after some minutes, a slow rise of the water begin, growing more and more rapid for about three hours, then gradually slackening for three more, until, as it nears six hours from the first observation, it again stands for some minutes when it begins to fall towards low water, accelerating as before for three hours, and then slacking off again. The two periods during which the water neither rises nor falls are called the *high water stand* and *low water stand*, or sometimes slack water, a term which, to avoid confusion, it is best to apply only to tidal currents. The varying rate of rise and fall of the tide differs much at different places. It is shown at New York and Liverpool in the diagrams, Nos. 1 and 2 on Plate IX. The hours are placed on the horizontal line, and the heights which the water reaches upon the staff on the vertical line. The curve shows the rate of rise and fall. The same result is given in Table A, where,



Digitized by Google

opposite to each hour, from low water is shown the height which the level of the water would mark upon a staff the 0 of which was at low water.

TABLE A.

Showing the rate of rise and fall of the tide at New York and Liverpool.

Hours before or after Low water.		Height of tide.	
		New York.	Liverpool.
	hrs.	ft.	ft.
Before.	6	4.2	18.9
	5	3.7	16.2
	4	2.9	10.4
	3	1.8	6.2
	2	0.9	3.0
	1	0.2	0.9
	0	0.0	0.0
After.	1	0.5	1.8
	2	1.6	5.6
	3	2.7	11.0
	4	3.6	16.1
	5	4.1	19.7
	6	4.4	20.7

This curve or this table will enable the navigator to conjecture the probable rise and fall from low or high water at ports where the rise and fall is about the same as at New York or at Liverpool, but will not apply to others.

If watching this tide staff from day to day in some port upon our coast we should note the time of high and low water, and the height beginning with, say, two days after change day of the moon, and continuing for a lunar month or twenty-eight days, we should find that on that day the lunitidal interval was nearly the average of all which we would obtain in the course of the month, and that the water rose higher and fell lower than at any other high and low water. These are *spring tides*. The interval would go on decreasing until two days before the first quarter, when it would reach its least value. The height of high water would decrease, and of low water increase, until one day after the first quarter, when the one would reach its least and the other its greatest height, corresponding to *neap tides*, or least rise and fall of the water. From the period of its least value to three days before the full the lunitidal interval would increase and then decrease, and so onward to two days after the full, when the interval would have its average value again, and the heights would again correspond to spring tides. The corresponding changes in the lunitidal intervals and heights take place from the full to change, passing through the moon's third quarter. It is hardly necessary to remind the navigator that at change the moon and sun cross the meridian together, or the hour of transit is 0 hrs., and that at the first quarter the hour of transit (moon's southing) is 6 hrs., at the full, 12 hrs. This change in the lunitidal interval runs its course from change to full or full to change, that is, in a half lunar month; it is hence called the half monthly inequality, and is in general the largest of the changes in the lunitidal interval, which must be taken into account.

If there were no changes in the lunitidal interval, it would be very simple to determine the time of high or low water at a place. A table of intervals and an almanac showing the time of transit, or as it is sometimes called in the almanacs the time of the moon's southing, would be all that is necessary. Suppose we wish to determine the time of high water at Boston on the 12th of December, 1859. From the table of establishments, No. LV., we take that of Boston, 11h. 27m.; from a Boston almanac, the time of the moon's upper transit on that day 1h. 59m., A. M., adding the two numbers we have 13h. 26m., or 1h. 26m., P. M., as the time of high water. The corresponding low water is 6h. after, or more exactly 6h. 13m. So, if the heights did not change, one number in the table would give us the rise and fall. This supposes that we had an almanac of the port at which we desired to know the time of high water, but as this would usually not be the case, we must take our result from the Nautieal Almanac, with which we are provided. This referring to the time of transit of the moon over the meridian of Greenwich, and to the same meridian for the longitude, 2m. must be added to the time of transit at Greenwich for every hour of west longitude, and subtracted for every hour of east longitude. The same result may be had from the table B, where the numbers to be added to the time of the moon's transit are given for every ten degrees of longitude.

Rule I.—Find the time of the moon's coming to the meridian of Greenwich, on the given day in the Nautical Almanac. Enter Table B and find the longitude of the given place in the left hand column, corresponding to which is a number of minutes to be applied to the time of passing the meridian at Greenwich, by *adding* when in *west* longitude, but *subtracting* when in *east* longitude; the sum or difference will be nearly the time that the moon passes the meridian of the given place.

To this corrected time add the time of high water or full sea from Table LV. The sum will be the time of high water on that day.

Example I.—Required the time of high water at Charleston (S. C.), November 19, 1859, in the afternoon, civil account. From the Nautical Almanac we find the moon's meridian passage at Greenwich, November 18, at 19h. 26m., which corresponds to 7h.

TABLE B.

Longitude of the place.	Correction of moon's passing the meridian.
deg.	min.
0	0
10	1
20	3
30	4
40	5
50	7
60	8
70	9
80	11
90	12
100	14
110	15
120	16
130	18
140	19
150	20
160	22
170	23
180	24

26m., A. M., of the 19th day by civil account. From Table LIV. we have the longitude of Charleston 79° 54′ W., which, for this purpose, may be assumed as 80°. Entering Table B with 80°, we find the correction of the moon's passing the meridian to be 11 minutes, which is to be added as the longitude is west. The moon's meridian passage at Charleston is therefore at 7h. 37m., A. M. Adding to this the lunitidal interval 7h. 13m. from Table LV. we obtain 14h. 50m., or 2h. 50m., P. M., as the time of high water at Charleston in the afternoon of November 19, 1859.

EXAMPLE II.—Required the time of high water at Portland (Maine), December 13, 1859, in the afternoon, civil account. The Nautical Almanac gives the moon's meridian passage at 14h. 47m. on the 12th, corresponding to 2h. 47m, A. M., on the 13th. The longitude of Portland is 70° 12′ W., in time (Table XXI.) 4h. 41m. At the rate of two minutes for every hour of west longitude we should add 9m. to the Greenwich time of the moon's meridian passage, giving it for Portland at 2h. 56m. Adding the lunitidal interval from Table LV. 11h. 25m., gives 14h. 21m., or 2h. 21m., P. M., for the time of high water on December 13th.

These results would be the time of high water, did not the lunitidal interval vary.

If the changes of lunitidal interval from half monthly inequality were the same for all ports, it would be easy by a table of a single column to apply the required correction to the time of high water when the moon was not at full or change, but this is not the case. It has been found, however, that the general law of this change is the same, and that by knowing the greatest and least lunitidal interval for any port we can determine by computation the change of interval. The ports having nearly the same difference of greatest and least interval are grouped together, and the correction to be applied to the establishment, according to the age of the moon, is given in Table C.

The ports which may thus be classed together are the following: *a.* The ports of England and of the western coast of Europe in general. *b.* The ports on the eastern or Atlantic coast of the United States. *c.* The ports of the western coast of Florida and of the western or Pacific coast of the United States.

This table is arranged on the supposition that the corrected establishment is used, which is the case for the more important ports in Table LV.

TABLE C.

Time of Moon's transit.	group (*a.*)	group (*b.*)	group (*c.*)
0h	add 41m	add 19m	0m
1	" 17	" 6	subt. 17
2	subt. 11	subt. 8	" 32
3	" 27	" 16	" 44
4	" 40	" 22	" 47
5	" 47	" 24	" 35
6	" 41	" 19	" 0
7	" 17	" 6	add 17
8	add 11	add 8	" 32
9	" 27	" 16	" 44
10	" 40	" 22	" 47
11	" 47	" 24	" 35

In other parts of the world than those mentioned in the groups *a*, *b*, *c*, the half-monthly inequality is little known; the following table, formed by averaging the three columns of Table C, will probably give a sufficient approximation. The corrections are to be applied to the *vulgar establishment.*

Time of moon's transit.	Correction.
0h	0m
1	subt. 18
2	" 37
3	" 49
4	" 56
5	" 55
6	" 40
7	" 22
8	" 3
9	add 9
10	" 16
11	" 15

Thus, in Example I., given before, the time of the moon's meridian passage being 7h. 37m., we enter the table with that quantity in the column of time of the moon's transit, and under the head of group *b*, and by an easy proportion we find the correction to the lunitidal interval to be, "add 3," that is, three minutes must be added to the mean lunitidal interval at Charleston, making it 7h. 16m., which, added to the time of moon's transit, would give 2h. 53m., P. M., as a more accurate time for the high water of November 19, 1859.

In Example II. we had the time of the moon's transit at Portland at 2h. 56m., entering Table C with 3h. in the column of moon's transit (which is near enough for this purpose), we find in the column of group *b* a correction of "subt. 16m.," *i. e.*, sixteen minutes must be subtracted from the mean lunitidal interval, making it 11h. 9m.,

which added to the time of moon's transit, gives 14h. 5m., or 2h. 5m., P. M., for the time of high water on December 13th.

The changes of the moon in declination cause a tide once in twenty-four lunar hours, which adds itself to the morning high water, increasing it, and subtracts itself from the next, or afternoon, high water, or vice versa. This is called the diurnal inequality. It affects the time and the height of both high and low water. In most of the ports of the Gulf of Mexico this diurnal tide is the only marked one, except when the moon is near the equator. In the ports of Great Britain and Ireland, France and Spain, the diurnal inequality in height is marked, but in time is inconsiderable. On the Atlantic coast of the United States it is small both in time and height. It increases in passing along the straits of Florida to the western coast of the Florida peninsula, and the semi-diurnal tides almost disappear from Cape San Blas to the mouths of the Mississippi, re-appearing only slightly between Isle Dernière and Galveston, and again being merged in the diurnal tide from Aransas Pass to Vera Cruz, and probably southward. The small tide of the day is frequently called by navigators a half tide, and in speaking of the large and small tides of the day they say the tide and half tide. On the western coast of the United States this inequality is large both in time and height, amounting at San Francisco at its greatest value to two and a half hours of time and four feet of height. It is probably large on the whole western coast of South America, but observations are wanting to give information in regard to the tides of these localities.

The following table will give the corrections for the daily inequality in time and height for the Pacific coast of the United States to within about eight minutes of time and and three inches of height.

TABLE D.

Days from moon's greatest declination.	Lunitidal intervals.		Heights.	
	High water.	Low water.	High water.	Low water.
	min.	min.	ft.	ft.
0	64	38	1.0	1.8
1	62	37	0.9	1.8
2	55	35	0.9	1.6
3	45	31	0.8	1.4
4	33	23	0.7	1.0
5	22	18	0.4	0.7
6	9	6	0.2	0.3
7	0	0	0	0

The quantities in this table are the corrections to be applied to the times of high or low water obtained by means of Rule I and corrected by Table C.

RULE.—Find from the Nautical Almanac the number of days elapsed since the moon's declination was greatest, or if before, the number of days to come to that time. With this enter Table D in the first column, and opposite the number find the correction in the second colum. When the moon's declination is north, the correction is to be subtracted; when south, it is to be added. When the moon's declination is nothing, the correction is nothing. The fourth and fifth columns give the corrections to the heights of mean high water and mean low water for the same days. The corrections for the height of low water follow the same rule as those for the times of high water; but for the heights of high water they are the contrary, that is, they are to be subtracted when the former are to be added, and vice versa.

The effects of this inequality may be also expressed in the following way: The moon's declination being north, the high water next following the moon's transit will be earlier and higher than the average, the next low water later and lower, the next high water later and lower, and the next low water earlier and higher; when the moon's declination is south, the first high water is later and lower, the next low water earlier and higher, the next high water earlier and higher, and the next low water later and lower, by the amounts given in the table.

EXAMPLE.—Required the time of high water at San Francisco, October 16, 1859. By Rule I., we find the moon's transit to happen at 3h. 21m., A. M., on that day. The establishment for San Francisco, from Table LV., is 12h. 6m., which added to 3h. 21m., gives 15h. 27m., or 3h. 27m., P. M., as the time of high water, uncorrected for the half monthly and diurnal inequalities. The former is obtained from Table C, group c, and is 45m., which is to be subtracted, giving 2h. 42m.; the second is obtained from Table D. By referring to the Nautical Almanac, we find that on the given day the moon had her greatest declination north. Entering, therefore, the table with 0 day from greatest declination, we find corresponding to it in the second column 64m., to be subtracted, as the declination is north, giving 1h. 38m. as the time of high water. If the corrections had been neglected, we should have been nearly two hours in error. The same table tells us in the other columns that this high water would be 1.0 foot higher than an average high water, and the next low water 1.8 foot lower. The next high water, A. M., of the 17th, would be one foot lower than the average, or two feet lower than the above high water, the next low water 1.8 feet higher than the average, or 3.6 feet higher than the preceding one.

Digitized by Google

CURRENTS.

A CURRENT is a progressive motion of the water, causing all floating bodies to move that way towards which the stream is directed. The *set of a current* is that point of the compass towards which the waters run, and its *drift* is the rate it runs per hour. The most usual way of discovering the set and drift of an unknown current, is the following, supposing the current at the surface to be much more powerful than at a great distance below the surface:—

Take a boat a short distance from the ship, and, by a rope fastened to the boat's stern, lower down a heavy iron pot or loaded kettle to the depth of 80 or 100 fathoms; then heave the log, and the number of knots run out in half a minute will be the miles the current sets per hour, and the bearing of the log will show the set of it.

There is a very remarkable current, called the *Gulf Stream*, which sets in an north-east direction along the coast of America, from Cape Florida towards the Isle of Sables, at unequal distances from the land, being about 75 miles from the shore of the southern States, but more distant from the shore of the northern States. The width of the stream is about 40 or 50 miles, widening towards the north.

We were first indebted to Doctor Franklin, Commodore Truxton, and Mr. Jonathan Williams, for the knowledge we possess of the direction and velocity of this stream. Its general course, as given by them, is marked on the chart affixed to this work. They all concur in recommending the use of the thermometer, as the best means of discovering when in, or near, the stream; for it appears, by their observations, that the water is warmer than the air when in the stream; and that at leaving it, and approaching towards the land, the water will be found six or eight degrees colder than in the stream, and six or eight degrees colder still when on soundings. Vessels coming from Europe to America, by the northern passage, should keep a little to the northward of the stream, where they may probably be assisted by a counter current. When bound from any southern port in the United States of America to Europe, a ship may generally shorten her passage by keeping in the Gulf Stream. By steering N. W. you will generally cross it in the shortest time, as its direction is nearly N. E. (*See page* 6, *Notes and Corrections.*)

In other parts of the Atlantic Ocean, the currents are variable, but are generally south-easterly along the coast of Spain, Portugal, and Africa, from the Bay of Biscay towards Madeira and the Cape de Verds. Between the tropics, there is generally a current setting to the westward.

There is also a remarkable current which sets through the Mozambique Channel, between the Island of Madagascar and the main continent of Africa, in a south-westerly direction. In proceeding towards Cape Lagullas, the current takes a more westerly course, and then trends round the cape towards St. Helena. Ships bound to the westward from India, may generally shorten their passage by taking advantage of this current. On the contrary, when bound to the eastward, round the Cape of Good Hope, they ought to keep far to the southward of it. However, there appears to be a great difference in the velocity of this current at different times; for some ships have been off this cape several days endeavoring to get to the westward, and have found no current; others have experienced it setting constantly to the westward, during their passage from the cape towards St. Helena, Ascension, and the West India Islands. Instances have however occurred, where an easterly current was experienced off the Cape of Good Hope. Off Cape Horn there is a current setting N. 80° E., at the rate of 12 miles the 24 hours, during the summer months—during the autumn months it is accelerated nearly double, and sets N. 49° E.

The following is compiled from a communication of Lieut. Bent to Mr. G. W. Blunt, respecting a stream of warm water, which is found on the east coasts of Formosa and the Japan Islands.

This stream has its origin in the great Equatorial current of the Pacific, from which it is separated by the south end of Formosa, whence it is deflected to the northward along the *east* coast of that island, until reaching the parallel of 26° north, when it bears off to the northward and eastward, washing the *whole south-east coast of Japan as far as the Straits of Sanger.*

Near its origin the stream is contracted, and seems to be usually confined be

Digitized by Google

tween the islands of Formosa and Majico-Suica, with a breadth of 100 miles; but to the northward of the latter it expands rapidly on its southern limit and reaches the Lew-Chew and Bonin groups, attaining a width to the northward of the latter of 500 miles. The *north-western* edge of the stream is strongly marked by a sudden change in the temperature of from 10° to 20°; but the south-eastern limit is less distinctly defined. Along the borders of the stream, and also in its midst, where whirls and eddies are produced by islands and inequalities in its bed, *strong tide rips* are encountered.

The average strength of the current between the south end of Formosa and the Straits of Sanger is from 35 to 40 miles per day. Its maximum once off the Gulf of Yedo was observed as high as 72, 74 and 80 miles respectively per day. A cold counter-current *may exist* to the north of 40° and long. 143°, running through the Straits of Sanger; but to the *westward* of a line connecting the north end of Formosa and the south-western extremity of Japan, a cold current sets to the southward, through the Formosa Channel, into the China Sea.

This current is well known to the navigators trading on the coast of China, who never, in the north-east monsoon, attempt to *beat* against it, but make the passage usually to the eastward of Formosa.

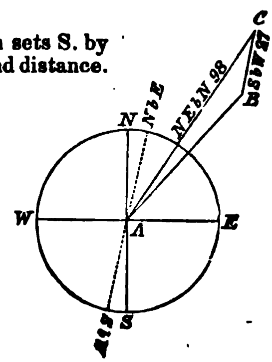
The Japanese call this warm stream, setting along their southern shores to the northward and eastward, the Kuro-Sicoo, or Black Stream, from its deep blue color Its maximum temperature is about 86°, and the difference between its temperature and that of the ocean due to the latitude is on an average about 12°.

There is *no counter-current* intervening between the Kuro-Sicoo and the coast of Japan south of the Straits of Sanger, consequently the large body of warm water which washes the shores of the island must essentially contribute in modifying its climate.

All cases of sailing in a current are calculated upon the principle that the ship is affected by it in the same manner as if she had sailed in still water, with an additional course and distance exactly equal to its set and drift. On this principle the projection and calculation of any problem of this kind may be easily made

EXAMPLE.

If a ship sail 98 miles N. E. by N., in a current which sets S. by W. 27 miles, in the same time, required her true course and distance.



BY PROJECTION.

Describe the compass NESW; through the centre A draw the N. E. by N. line AC equal to 98 miles; through C draw the line BC parallel to the S. by W. line, make BC equal to 27 miles, and join AB. Then AB will be the course and distance made good; and by measuring, we find the course to be N. E. ¼ N., the distance 74 miles.

BY CALCULATION.

The shortest method of calculating this problem, is by means of Table I., as in the adjoined Traverse Table; putting in it the course sailed by the ship, and the set of the current; then finding the difference of latitude and departure by the table. The course and distance made good is then found as in Case VI. of Plane Sailing. In the present example, the course is N. E. ¼ N., and the distance 74 miles nearly.

TRAVERSE TABLE.

Courses.	*Dist.*	N.	S.	E.	W.
N. E. by N. S. by W.	98 27	81.5	 26.5	54.4	 5.3
		81.5 26.5	26.5	54.4 5.3	5.3
Diff. Lat...55.0			Dep. 49.1		

OF THE LOG-LINE AND HALF-MINUTE GLASS.

Various methods have been proposed for measuring the rate at which a ship sails but that most in use is by the Log and Half-Minute Glass.

The Log is a flat piece of thin board, of a sectoral or quadrantal form (see Plate VI. fig. 3), loaded, on the circular side, with lead sufficient to make it swim upright in the water. To this is fastened a line, about 150 fathoms long, called the *log-line*, which is divided into certain spaces called *knots*, and is wound on a reel (see Plate VI. fig. 4) which turns very easily. The Half-Minute Glass is of the same form as an Hour Glass (see Plate VI. fig. 2), and contains such a quantity of sand as will run through the hole in its neck in half a minute of time.

The making of the experiment to find the velocity of the ship, is called *heaving the log*, which is thus performed:—One man holds the reel, and another the half-minute glass; an officer of the watch throws the log over the ship's stern, on the lee side, and when he observes the stray line is run off (which is about ten fathoms, this distance being usually allowed to carry the log out of the eddy of the ship's wake), and the first mark (which is generally a red rag) is gone off, he cries, *Turn;* the glass-holder answers, *Done;* and, watching the glass, the moment it is run out, says, *Stop*. The reel being immediately stopped, the last mark run off shows the number of knots, and the distance of that mark from the reel is estimated in fathoms. Then the knots and fathoms together show the distance the ship has run the preceding hour, if the wind has been constant. But if the gale has not been the same during the whole hour, or interval of time between heaving the log, or if there has been more sail set or handed, a proper allowance must be made. Sometimes, when the ship is before the wind, and a great sea setting after her, it will bring home the log. In such cases, it is customary to allow one mile in ten, and less in proportion if the sea be not so great. Allowance ought also to be made, if there be a head sea.

This practice of measuring a ship's rate of sailing, is founded upon the following principle—that the length of each knot is the same part of a sea mile, as half a minute is of an hour. Therefore the length of a knot ought to be $\frac{1}{120}$ of a sea mile; but, by various admeasurements, it has been found that the length of a sea mile is about $6086\frac{7}{10}$ feet; hence the length of a sea knot should be 51 feet. Each of these knots is divided into 10 fathoms, of about 5 feet each. If the glass be only 28 seconds in running out, the length of the knot ought to be 47 feet and 6 tenths. These are the lengths generally recommended in books of navigation; but it may be observed, that, in many trials, it has been found that a ship will generally overrun her reckoning with a log-line thus marked; and, since it is best to err on the safe side, it has been generally recommended to shorten the above measures by 3 or 4 feet, making the length of a knot about $7\frac{1}{2}$ fathoms, of 6 feet each, to correspond with a glass that runs 28 seconds.

In heaving the log, you must be careful to veer out the line as fast as the log will take it; for if the log be left to turn the reel itself, the log will come home and deceive you in your reckoning. You must also be careful to measure the log-line pretty often, lest it stretch and deceive you in the distance. Like regard must be had that the half-minute glass be just 30 seconds; otherwise no accurate account of the ship's way can be kept. The glass is much influenced by the weather, running slower in damp weather than in dry. The half-minute glass may be examined by a watch, with a second hand, or by the following method:—Fasten a plummet on a line, and hang it on a nail, observing that the distance between the nail and middle of the plummet be $39\frac{1}{8}$ inches; then swing the plummet, and notice how often it swings while the glass is running out. and that will be the number of seconds measured by the glass.

Digitized by Google

To correct the distance when the log-line and half-minute glass are faulty

If there be any error in the log-line or glass, the measured distance must be corrected in the following manner, supposing that a 30″ glass requires 50 feet to a knot:—

(1.) If the glass only is faulty, you must say, *As the seconds run by the glass are to 30 seconds, so is the distance given by the log to the true distance.* Thus, if a ship sails 8½ knots per hour, by a glass of 36 seconds, the true number of knots per hour will be 7.1; for 36 : 30 :: 8.5 : 7.1.

(2.) If the log-line only is faulty, you must say, *As fifty feet is to the distance of a knot on the line, so is the distance run by the log to the true distance.* Thus, if a ship sails 7 knots per hour, by a log-line measuring 53 feet, her true distance will be 7.4 miles per hour; because 50 : 53 :: 7 : 7.4.

(3.) If the log-line and glass are both faulty, you must say, *As 50,* multiplied by the length of the glass, is to 30, multiplied by the length of the line, so is the measured to the true distance.* Thus, if a ship sails 6 knots per hour, with a glass of 24 seconds, and a log-line of 60 feet per knot, her true velocity will be 9 miles per hour, because 50 × 24 : 30 × 60 :: 6 : 9.

The following description of Massey's Patent Log, used in surveying operations, is from Capt. Edward Belcher's treatise on Nautical Surveying:—

"It is composed of a brass wedge-shaped box, having within, three cogged wheels, acting on each other in such proportion that a total revolution of one completes a division of the next, (or one-twentieth,) a revolution of the next one-eighth, registering thus from one hundred and sixty miles to tenths, and decimal parts; the action is by the rotation of a spindle with four spirally fixed wings, (termed the rotator, or fly,) which turns an endless screw in the box, acting directly on the decimal wheel. It is towed astern by a stout lead line of sixty fathoms, and is registered every time the course is changed, angles taken, &c., but should not be reset until the twenty-four hours have elapsed, the ship anchors, or goes less than three knots—(when it becomes uncertain from not towing horizontally.)"

A new instrument for measuring the vessel's velocity, and also to find the depth of water by sounding, has been invented by Professor W. P. Trowbridge of the United States Coast Survey. It is more accurate than any other instrument used for such purposes, and has been adopted by the United States Navy Department.

* Instead of multiplying the length of the glass by 50, and the line by 30, you may multiply the former by 5, and the latter by 3. If any one chooses to mark the log-line at less than 50 feet for a glass of 30 seconds, he must put his estimated length of the knot, instead of 50, in all the above rules.

TABLE,

Showing the length of a mile of Longitude, in feet, for different Latitudes.

[A Geographical or Nautical Mile at the Equator is 6086.4.]

Lat.	Eng. feet.	Lat.	Eng. feet.	Lat.	Eng. feet.	Lat.	Eng. feet.	Lat.	Eng. feet.	Lat.	Eng. feet.
0	6086	15	5880	30	5275	45	4311	60	3051	75	1580
1	6086	16	5852	31	5222	46	4235	61	2958	76	1477
2	6083	17	5822	32	5166	47	4158	62	2865	77	1374
3	6078	18	5790	33	5110	48	4080	63	2771	78	1269
4	6072	19	5757	34	5051	49	4001	64	2675	79	1165
5	6063	20	5722	35	4991	50	3920	65	2579	80	1060
6	6053	21	5685	36	4930	51	3838	66	2482	81	955
7	6041	22	5646	37	4867	52	3755	67	2385	82	850
8	6028	23	5605	38	4802	53	3671	68	2287	83	744
9	6015	24	5663	39	4736	54	3585.	69	2188	84	638
10	5995	25	5519	40	4669	55	3499	70	2088	85	532
11	5975	26	5474	41	4600	56	3411	71	1987	86	426
12	5954	27	5427	42	4530	57	3323	72	1887	87	320
13	5931	28	5378	43	4458	58	3233	73	1785	88	213
14	5907	29	5327	44	4385	59	3142	74	1683	89	107
15	5880	30	5275	45	4311	60	3051	75	1580	90	000

Digitized by Google

DESCRIPTION AND USE OF A QUADRANT OF REFLECTION.

Mr. John Hadley was the first who published a description of the *Quadrant of Reflection*, for measuring angular distances; and the instrument still bears his name, although it has been ascertained that Sir *Isaac Newton* invented a similar one some years before, but never made it public. One of our countrymen, Mr. *Thomas Godfrey*, of Philadelphia, had also contrived an instrument, on the same principles, some time before Mr. Hadley made known his discovery.

Plate IX., figure 1, represents a quadrant of reflection, the principal parts of which are, the frame ABC, the graduated arc BC, the index D, the nonius or vernier scale E, the index glass F, the horizon glasses G and H, the dark glasses or screens I, and the sight vanes K and L.

The *graduated arc* BC is an octant, or eighth part of a circle, but, on account of the double reflection, is divided into 90°, numbered from 0° towards the left, and each degree is commonly divided into three equal parts, of 20 minutes each. The graduation on the limb is continued a few degrees to the right of 0°. This portion is called the *arc of excess*, and is found very convenient for several purposes.

The *index* D is a flat bar, commonly made of brass, movable round the centre of the instrument, and broader towards the axis of motion, where is fixed the index glass F; at the other end is fixed the nonius or vernier scale, used in estimating the subdivisions of the arc; at the bottom or end of the index, there is a piece of brass which leads under the arc, having a spring to make the vernier lie close to the limb, and a screw to fasten it in any position. Some quadrants have a tangent screw affixed to the lower part of the index to adjust its motion. The *vernier* is a small, narrow slip of brass or ivory, fixed to that part of the index which slides over the graduated arc, and usually contains a space equal to 21 or 19 divisions of the limb, and is divided into 20 equal parts. Hence the difference between a division on the limb, and a division on the dividing scale, is one twentieth of a division of the limb, or one minute. Therefore, if any division on the vernier is in the same straight line with a division of the limb, then no other division on the vernier can coincide with a division of the limb, the extreme divisions excepted. Some time ago, it was usual to reckon the divisions on the vernier from its middle towards the right, and from the left towards the middle; but, this being found inconvenient, a more commodious method has been introduced of numbering from right to left. Hence the degree and minute pointed out by the vernier, may be found thus:—Observe what minute on the vernier coincides with a division on the limb; then this minute, being added to the degree and parts of a degree on the limb immediately preceding the first division on the vernier, will be the degree and minute required. Thus, suppose 10′ on the vernier coincides with a division on the limb, and that the division on the limb preceding the first division of the vernier is 8° 20′; the division pointed out by the vernier will be 8° 30′.

The *index glass* F is a plane speculum or mirror of glass, quicksilvered and set in a brass frame. It is so placed that the face of it is perpendicular to the plane of the instrument, and is fixed to the index by the screw M; the other screw N serves to replace it in a perpendicular position, if, by any accident, it has been put out of order. The use of this mirror is to receive the rays from the sun, or other object observed, and reflect them towards the horizon glasses.

The *horizon glasses* G and H are two small speculums. G is called the *fore horizon glass*, from its being used in the common or *fore observation*, where the observer's face is turned towards the object; and H the *back horizon glass*, being used in the *back observation*, where the observer's back is turned towards the object. These mirrors receive the reflected rays from the index glass, and reflect them to the eye of the observer. The horizon glasses are not entirely quicksilvered. The fore horizon glass G is only silvered on the lower half, the other half being transparent, and the back part of the frame cut away, that the horizon, or any other object, may be seen

Digitized by Google

through it. The back horizon glass H is silvered at both ends; in the middle is a transparent slit, through which the horizon may be seen. These two glasses are set in brass frames, similar to that of the index glass, and fixed on movable bases, which are adjusted by screws so as to set the glasses in their true positions. In general there are three *dark glasses* or screens, I; two red ones, of different shades, and one green. Each is set in a brass frame, which turns on a centre, that they may be used separately or together They serve to defend the eye from the rays of the sun during an observation. The green glass is peculiarly adapted to take off the glare of the moon, but may be used for the sun when much obscured by clouds. When these glasses are used for a fore observation, they are to be fixed as in figure 1; but when used for a back observation, they are to be placed at O.

The *sight vanes*, K and L, are pieces of brass, standing perpendicular to the plane of the instrument. The vane K is called the *fore sight vane*, and L the *back sight vane* There are two holes in the fore sight vane, the lower of which and the upper edge of the silvered part of the fore horizon glass are equidistant from the plane of the instrument, and the other hole is opposite to the middle of the transparent part of that glass. The back sight vane has one perforation, which is exactly opposite to the middle of the transparent slit in the back horizon glass.

The *adjusting lever* (fig. 2), which is fixed on the back of the quadrant, serves to adjust the horizon glass, by placing it parallel to the index glass. When this lever is to be made use of, the screw B must be first loosened; and when, by the adjuster A, the horizon glass is sufficiently moved, the screw B must be fastened again; by this means the horizon glass will be kept from changing its position.

To adjust a quadrant.

As the quadrant, from various accidents, is liable to be out of order, it is necessary that the mariner should be able to ascertain the errors, and re-adjust the several parts, before he proceeds to make his observations. For this purpose, he must examine whether the index glass and the horizon glasses be perpendicular to the plane of the instrument, and whether the plane of the fore horizon glass be parallel, and that of the back horizon glass perpendicular to the plane of the index glass, when 0 on the vernier stands against 0 on the limb.

1st. *To ascertain whether the index glass be perpendicular to the plane of the quadrant.*

Place the index on the middle of the arc, and hold the index glass near the eye. Look into it, in a direction parallel to the plane of the instrument, and see if the reflected arc appear exactly in a line with the arc seen direct, or if the image of any point of the arc near B appear of the same height as the corresponding part of the arc near C seen direct; if so, the index glass is perpendicular to the plane of the quadrant; if not, the error must be rectified by the screws on the base, behind the frame, by loosening the screw M, and tightening the screw N, or by loosening the screw N, and tightening the screw M.

2d. *To ascertain whether the fore horizon glass be perpendicular to the plane of the quadrant.*

Having adjusted the index glass, hold the instrument in a vertical position Look through the fore sight vane, and move the index till the reflected and direct images of the horizon, seen in the horizon glass, coincide. Then incline the instrument till its plane is nearly parallel to the horizon: if the images still coincide, the horizon glass stands perpendicular; otherwise it does not, and must be adjusted by the screws placed before and behind it, loosening one of them, and tightening the other.

This adjustment may be made by the sun, moon, or a star, by holding the quadrant in a vertical position, and observing if the object seen by reflection appears to the right or left of the object seen direct, and moving the screws, as above, till both images coincide.

After having made the horizon and index glasses parallel, according to the directions in the following article, it will be best to re-examine this adjustment.

3d. *To make the horizon glass parallel to the index glass, when 0 on the vernier stands on 0 on the arc.*

Having fixed the index, so that 0 on the vernier stands on 0 on the arc, look at any distant object, and see if the image of it coincides with the object itself; if it does, the

Digitized by Google

adjustment is complete; if not, they must be made to coincide by means of the adjusting lever. The horizon may be used for this purpose in the following manner:—Hold the plane of the instrument vertical; look through the lower hole in the vane K, and direct the sight through the transparent part of the glass G to the horizon; then if the horizon line, seen in the silvered and transparent part, coincides, or makes one straight line, the horizon glass is said to be adjusted; but if the horizon lines do not coincide, slacken the screw B (fig. 2) in the middle of the adjusting lever, and turn the horizon glass on its axis until the horizon lines coincide; then fix the lever firmly by tightening the screw B. If this adjustment be again examined, it will perhaps be found imperfect. In this case, therefore, it remains either to repeat the adjustment, or find the error of it (usually called the *index error*), which may be done thus:—Let the horizon glass remain fixed, and move the index till the image and object coincide; then the difference between 0 on the vernier and 0 on the arc is the index error, which is to be added to the angle or altitude observed, if the 0 on the vernier be to the right hand of 0 on the arc, otherwise to be subtracted. Thus, if the horizon is used, the instrument being held in a vertical position, you must look through the lower hole of the vane K, towards the horizon; then move the index till the reflected and direct images of the horizon coincide; the difference between 0 on the vernier and 0 on the arc will be the index error.

4th. *To adjust the back horizon glass, that it may be perpendicular to the plane of the index glass, when* 0 *on the vernier stands on* 0 *on the arc.*

Set the index as far to the right of 0 on the arc, as twice the dip of the horizon (taken from Table XIII.); hold the quadrant in a vertical position; look towards the horizon through the hole in the back horizon vane L, and the transparent slit of the back horizon glass H; then, if the reflected horizon, which will appear inverted, coincide with that seen direct, the glass is truly adjusted; otherwise the screw, in the centre of the lever on the under side of the quadrant, must be slackened, and the glass turned on its axis till both horizons coincide, when the lever should be fixed by tightening the screw.

5th. *To adjust the back horizon glass, that it may be perpendicular to the plane of the quadrant.*

Put the index on 0; hold the quadrant nearly parallel to the horizon; look through the hole on the back sight vane, and if the true and reflected horizons appear in the same straight line, the glass is perpendicular to the plane of the instrument; but if they do not coincide, the sunk screws, before and behind the glass, must be turned till both appear to form one straight line.

To take an altitude of the sun by a fore observation.

If the sun is bright, turn down one or more of the dark glasses; hold the instrument in a vertical position; apply the eye to the upper hole in the fore sight vane, when the image is so bright as to be seen in the transparent part of the fore horizon glass, otherwise to the lower hole; direct the sight to that part of the horizon beneath the sun, and move the index till you bring the image of his lower limb to touch the horizon directly under it; but as this point cannot be exactly ascertained, the observer should move the instrument round to the right and left a little, keeping, as nearly as possible, the sun always in that part of the horizon glass which is at the same distance as the eye from the plane of the quadrant;* by this motion the sun will appear to sweep the horizon, and must be made to touch it at the lowest part of the arc; the degrees and minutes pointed out by the index, will be the observed altitude of the sun's lower limb at that instant.

To take an altitude of the moon by a fore observation.

In the night, when the moon is bright, her image may be seen in the transparent part of the fore horizon glass, and the observation may be taken exactly in the same

---

* In common quadrants, if the upper hole be looked through, the sun's image must be made to appear in the middle of the transparent part of the horizon glass; but if the lower hole be looked through, the image must be made to appear on the line joining the silvered and transparent parts of the horizon glass, as these parts of the horizon glass are at the same distances from the plane of the instrument, as the holes of the sight vanes respectively.

Digitized by Google

manner as an observation of the sun. If the image is so faint as not to be seen in the transparent part of the horizon glass, you must set the index to 0; hold the plane of the quadrant in a vertical position; direct the sight to the moon, and, at the same time, look for her reflected image in the silvered part of the horizon glass; move the index forward till the moon's image (which will appear to descend) just touches the horizon; then sweep the quadrant as in observing the sun, and bring her round limb in contact with the horizon, whether it be her upper or lower. The degrees and minutes pointed out by the index, will be the observed altitude of that limb which was brought in contact with the horizon.

To take an altitude of a star by a fore observation.

This is done exactly in the same manner as in observing the moon's altitude, when her image is so faint as not to be seen in the transparent part of the horizon glass.

To take the sun's altitude by a back observation.

Put the dark glasses in the hole O, and turn one or more of them down, according to the brightness of the sun; then, holding the instrument in a vertical position, look through the back sight vane towards that part of the horizon opposite the sun; move the index till the sun's image is seen in the silvered part of the glass; give the quadrant a slow vibratory motion, and the sun will appear to describe an arc with its convex side upward; bring the upper limb, when in the upper part of this arc, in contact with that part of the horizon seen through the transparent slit, and the degrees and minutes pointed out by the index will be the altitude of the sun's lower limb. The altitude of the moon, or a star, may be obtained in the same manner, only observing to bring the round edge of the moon to the horizon.

The back observation is but little used, on account of the difficulty of adjusting and observing. Various remedies have been proposed for these defects, but none have yet been generally adopted. The back observation of the altitude of any object, is useful only when there is not an open horizon for the fore observation; but even in that case, the fore observation may often be used, if the distance of the horizon be known, as will be explained hereafter.

To observe the meridian altitude of any celestial object by a fore observation.

When the object rises and sets, it comes to the meridian above the horizon only once in 24 hours, and is then at its greatest altitude; and by observing it, the latitude may be easily determined. The sun comes to the meridian exactly at noon, or 12 o'clock apparent time; the moon and stars at various hours. To observe the meridian altitude, begin a few minutes before the time of passing the meridian; bring the object to sweep the horizon, according to the preceding directions; this operation must be repeated until the object begins to descend below the edge of the sea; the degrees and minutes then shown by the index will be the meridian altitude.

If the object does not set, it comes to the meridian below the pole, and is then at its least altitude; this altitude may be observed as above directed, with this difference, that you must continue sweeping till the object begins to rise above the edge of the sea, instead of descending below it.

The meridian altitude of any object may be taken in a similar manner by a back observation.

Strictly speaking, this method of finding the meridian altitude is not absolutely accurate, except the ship be at rest, and the sun's declination constant. For if the ship is sailing towards the sun, the altitude will be increased; but the altitude will be decreased in sailing from the sun. The correction of altitude arising from this source is generally very small, and it may be neglected in most cases, as will be shown hereafter.

Advice to seamen in the choice of a quadrant.

The joints of the frame must be close, without the least opening or looseness, and the ivory on the arc inlaid and fixed, so as not to rise in any place above the plane of the instrument; all the divisions of the arc and vernier must be exceedingly fine and straight, so that no two divisions of the vernier (except the first and last) coincide, at the same time, with the divisions of the arc. All the glasses belonging to the quadrant

Digitized by Google

should have their surfaces perfectly plane, and their fore and back surfaces exactly parallel; this may be verified, in the horizon glass and index glass, by means of two distant objects, in the following manner:—Move the index till both objects are exactly in contact, at the upper edge of the silvered part of the horizon glass; then move the quadrant in its own plane, so as to make the united images move along the line, separating the silvered from the transparent part of the horizon glass; and if, in this motion, the images continue united, the reflecting surfaces are good planes, otherwise the planes are imperfect. To examine the dark glasses, we must bring the image of a distant object to coincide with the object seen directly; then turn the colored glass so that the plane which was next to the index glass may now be next to the horizon glass, and if the direct and reflected images still coincide, the surfaces of the glass are parallel.

Digitized by Google

DESCRIPTION AND USE OF A SEXTANT OF REFLECTION.

A Sextant is constructed on the same principles, and may be used for measuring altitudes in the same manner, as a quadrant.* The arc of a sextant, as its name implies, contains 60°, but, by reason of the double reflection, is divided into 120°. This instrument is particularly intended to measure the distance of the moon from the sun, a planet, or a fixed star; and as that distance is wanted as accurately as possible, to determine the longitude of the place of observation, the instrument is constructed with more care, and is provided with some additional appendages that are not in the quadrant. Plate IX., figure 3, represents a sextant, the frame being generally made of brass, or other hard metal; the handle at its back is made of wood. When observing, the instrument is to be held with one hand, by the handle, while the other hand moves the index. The arc AA is divided into 120°, each degree into 3 parts of 20 minutes each, and the vernier scale is in general so divided as to show half or a quarter of a minute. In some sextants, the degree is divided into six equal parts, of 10′ each, and the vernier shows 10″.

In order to observe with accuracy, and make the images come precisely in contact, a *tangent screw* B is fixed to the index, and by this it can be moved with greater regularity than it can be by hand; but the screw B does not act until the index is fixed by the screw C, at the back of the sextant. Care must be taken not to force the tangent screw, when it arrives at either extremity of its arc. When the index is to be moved any considerable quantity, the screw C must be loosened; and when the index is brought nearly to the division required, the back screw C must be tightened, and then the index moved gradually by the tangent screw.

In many sextants, the lower part of the index glass, or that next the plane of the instrument, is silvered as usual, and the back surface of the upper part painted black; a screen, painted black, is fixed by its axis to the base of the index glass, and may be placed over the silvered part when the rays are strong; in this case, the image is to be reflected from the outer surface of the upper part, and the error which might possibly arise from the planes of the glass not being parallel, is thereby avoided.

The colored glasses are similar to those applied to a common quadrant, and are usually four in number, placed at D, to screen the eye from the solar rays, and the glare of the moon; they may be used separately or together, as occasion requires. In addition to these, there are three similar glasses, placed behind the horizon glass, to be used in finding the index error by means of the sun, and in observing the sun's altitude, by an artificial horizon on land. The paler glass is sometimes used in observing altitudes at sea, to take off the strong glare of the horizon below the sun, arising from the sun's light, reflected irregularly from the small rippling waves—an appearance which has lately been called *kumatage*.

A sextant is generally furnished with a tube without glasses, and two telescopes, the one representing the objects erect or in their natural situation, the other inverting them,

* There is not, in general, any apparatus for the back observation fixed to a sextant; but if the altitude of any celestial object be greater than 60°, the supplement of the altitude may be obtained by a back observation, with a sextant, with ease and accuracy; and as this method may be often used with advantage, when a fore observation cannot be obtained, we shall here point out the method of taking the observation, and shall hereafter give the calculations for determining the latitude from a meridian observation taken in this manner:—The back of the observer being turned to the sun, he must move the index till the image of the sun touches the edge of the back horizon, and then move the sextant a little to the right and left (as in a fore observation), and the image will describe an arc with the convex side upward; move the index till the lower limb of the image, when in the upper part of the arc, just touches the horizon, and the observation will be complete; observing that, if the telescope be used, the image must be brought in the middle between the two parallel wires; but if the telescope be not used, the image of the sun must be seen in the horizon glass, at the same distance from the plane of the instrument as the eye of the observer. The altitude thus obtained will be the supplement of the altitude of the sun's upper limb. The corrections to be applied to obtain the true central altitude, will be given hereafter.

Digitized by Google

the eye-glass being fixed in a movable tube, in order to adjust the telescope to a proper focus. By means of these telescopes, the line of sight may be rendered parallel to the plane of the instrument, and the contact of the limbs of any two objects more accurately observed. The tube, or either telescope, is to be screwed into a brass ring, which is connected with another brass ring by means of two screws; and by loosening one, and tightening the other, the axis of the tube or telescope may be set parallel to the plane of the instrument. One of these rings is fixed to a brass stem, which slides in a socket; and by means of the screw L, at the back of the sextant, it may be raised or lowered so as to move the axis of the telescope to point to that part of the horizon glass judged the most fit for observation.

A circular head, containing a plate, in which there are three colored glasses, and a part that is open, sometimes accompanies the sextant; this head is to be screwed on the eye end of the tube, or on that of either telescope. The edge of the plate projects a little beyond the head on one side, and is movable by the finger, so that the open ring, or any of the colored glasses, may be brought between the eye-glass of the telescope and the eye; this answers the purpose of the dark glasses placed at E, in adjusting by the sun, or observing by an artificial horizon on land.

To these are added a small screw-driver, to adjust the screws, and a magnifying glass, to read off the observation with greater accuracy.

The adjustments of a sextant are similar to those of a quadrant; the index and horizon glasses must be perpendicular to the plane of the instrument, and their planes parallel to each other when the index stands on 0; also the axis of the telescope must be set parallel to the plane of the instrument; each of these particulars must be examined before an observation is taken and the adjustments, if requisite, made according to the following directions:—

1st. *To set the index glass perpendicular to the plane of the instrument.*

Move the index forward to about 60°, and proceed exactly in the manner prescribed for the adjustment of the index glass of a quadrant, page 129.

2d. *To make the horizon glass perpendicular to the plane of the sextant.*

This adjustment is made exactly in the same manner as that of the quadrant, described in page 129, except that, instead of looking through the sight vane, you may use the tube, or a telescope.

To make the horizon glass and index glass parallel when the index is on 0.

Having made the foregoing adjustments, set the first division on the index at 0 on the limb; fasten the index in this position, and make the coincidence of these divisions as perfect as possible, by means of the tangent screw, the eye being assisted by the magnifying glass; screw the tube, or telescope, into its support, and turn the screw L, at the back of the instrument, till the line which separates the transparent and silvered parts of the horizon glass appears in the middle of the tube or telescope; having done this, hold the plane of the sextant vertically, and direct the sight through the tube or telescope to the horizon; then, if the reflected and true horizons do not coincide, turn the tangent screw at the back of the horizon glass till they are made to appear in the same straight line. Then will the horizon glass be adjusted.

After the screw that retains the horizon glass in its place is fastened, it will be proper to re-examine this adjustment; if the coincidence of the horizons is not perfect, the adjustment must be repeated till it is so; but as it is difficult to obtain a perfect coincidence by this means, the horizons may be brought to coincide by turning the tangent screw of the index; and the difference between the 0 on the arc and the 0 on the vernier will be the index error, which is additive to all observations if the 0 of the index stand on the extra arc, otherwise subtractive. The index error may also be found very accurately, by measuring the diameter of the sun twice, with a motion of the index in contrary directions; that is, first bring the upper limb, seen by reflection, to coincide with the lower limb seen directly; then bring the lower limb by reflection to coincide with the upper seen directly. If both these measures are taken either to the right or left of 0 on the limb, half their sum will be the index error; additive if to the right of 0, subtractive if to the left: but if one of the measures be taken to the right, and the other to the left of 0, half their difference will be the index error, which will be additive when the diameter measured to the right of 0 exceeds that measured to the left, otherwise subtractive. Thus, if the measures were 38′ to the left of 0 on

Digitized by Google

he arc, and 26′ to the right* on the extra arc, half the difference, or 6′, would be the correction, subtractive. In some sextants, the horizon glass cannot be adjusted; the index error must in that case be found, and must be considered as a constant quantity to be applied to all angles measured with the same instrument.

To set the axis of the telescope parallel to the plane of the sextant.

In measuring angular distances, the line of sight, or axis of the telescope, must be parallel to the plane of the instrument, as a deviation in that respect, in measuring large angles, will occasion a considerable error. To avoid this, a telescope is made use of, in which are placed two wires, parallel to each other, and equidistant from the centre of the telescope; by means of these wires, the adjustment may be made in the following manner:—Screw on the telescope, and turn the tube containing the eye-glass till the wires are parallel to the plane of the instrument; then select two objects, as the sun and moon, whose angular distance must not be less than 90°, because an error is more easily discovered when the distance is great; bring the reflected image of the sun exactly in contact with the direct image of the moon, at the wire nearest the plane of the sextant, and fix the index; then, by altering a little the position of the instrument, make the objects appear on the other wire; if the contact still remains perfect, the axis of the telescope is in its right situation; but, if the limbs of the two objects appear to separate or lap over, at the wire which is farthest from the plane of the sextant, the telescope is not parallel, and it must be rectified by turning one of the two screws of the ring into which the telescope is screwed and fixed, having previously unturned the other screw; by repeating this operation a few times, the contact will be precisely the same at both wires, and the axis of the telescope will be parallel to the plane of the instrument.†

In order to estimate the error committed in not observing the contact of the objects in the middle, between the two parallel wires of the telescope, it is necessary to know the angular distance of these wires. This may be found as follows:—Turn round the eye-piece of the telescope, till the wires are perpendicular to the plane of the instrument; hold the instrument in a vertical position, and move the index till the direct and reflected images of the horizon appear in the same line, which will happen when the index is at 0, if the instrument be well adjusted; then move the index till the reflected image of the horizon be at one wire, and the direct image at the other; the angle moved through by the index, as shown by the divisions of the arc, will be the angular distance of the two wires. This angular distance being obtained, the observer may, by means of it, estimate, at each observation, how much the place where the contact is observed is elevated above, or depressed below, the plane passing through the eye and the middle line between the two parallel wires; the correction in Table XXXV., corresponding to this angle, is to be subtracted from the observed angular distance of the objects. Thus, if the distance between the wires be 3°, one of them will be elevated above the plane 1° 30′, and the other depressed as much below it; and if, in taking an observation, the point of contact is estimated to be one third part of the distance from the middle towards either wire, the angle of elevation or depression will be one third part of 1° 30′, or 30′; and if the observed distance be 100°, the correction in Table XXXV. will be 19″, subtractive from the observed angle, which will therefore be $100° - 19'' = 99° 59' 41''$. In general, it will not be necessary to attend to this correction.

To measure the distance between the sun and moon.

Screw on the telescope, and place the wires parallel to the plane of the instrument; then, if the index glass is half silvered and half blacked, and the sun very bright, raise the plate before the silvered part of the glass, and, with the screw L, raise the telescope

* In reading off the measure on the extra arc, you must reckon the minutes on the vernier from left to right, counting 19′ as 1′, 18′ as 2′, &c., or else take the difference between the minutes denoted by the vernier and 20′. Thus, if the angle on the extra arc appeared by the nonius to be 14′, the real angle would be only 6′.

† This adjustment may be made in a manner similar to that by which the graduation on the frame of the telescope of a circular instrument is verified, by using the adjusting tools of a circle or a ruler whose surfaces are perfectly parallel to each other. Thus, lay the sextant horizontally on a table, and place the ruler on the limb or plane of the instrument, and, at about 12 or 15 feet distance, let a well-defined mark be placed in a range with the telescope, so as to be in the same straight line with the top of the ruler; then raise or lower the telescope, by means of the screw L, till the centre of the eye-piece of the telescope be at the same height as the top of the ruler; then, if the mark be seen in the middle between the wires of the telescope, it is well adjusted; if not, it must be altered by means of the screws of the ring into which the telescope is screwed.

Digitized by Google

to the transparent part of the horizon glass; turn down one or more of the dark glasses, according to the brightness of the sun; then hold the sextant so that its plane may pass through the sun and moon; if the sun be to the right hand of the moon, the sextant is to be held with its face upwards; if to the left hand, the face is to be held downwards; with the instrument in this position, look directly at the moon through the telescope, and move the index forward till the sun's image is brought nearly into contact with the moon's nearest limb; then fix the index by the screw under the sextant, and make the contact perfect by means of the tangent screw; at the same time, move the sextant slowly, making the axis of the telescope the centre of motion; by this means the objects will pass each other, and the contact be more accurately made; observing that the point of contact of the limbs must always be observed in the middle between the parallel wires. The observation being thus made, the index will point out the distance of the nearest limbs of the sun and moon.

To measure the distance between the moon and a star.

Turn down one of the screens, if the moon is bright, and direct the plane of the instrument through both objects, with its face upwards, if the moon is to the right of the star; but if to the left, the face is to be held downwards; look at the star through the telescope and transparent part of the horizon glass, and move the index till the moon's image appears nearly in contact with the star; fasten the index, move the sextant round the axis of the telescope, as in measuring the distance of the sun and moon, and turn the tangent screw, till the coincidence of the star, and the *enlightened* or *round limb* of the moon is perfect; observing that the point of contact of the limb of the moon and star must always be in the middle between the parallel wires. The observation being thus made, the index will point out the distance of the enlightened limb of the moon from the star, whether it be the farthest or nearest limb.

Verification of the parallelism of the index glass.

This verification is to be made ashore, by observing the angular distance of two well-defined objects, whose distance exceeds 90° or 100° (having previously well adjusted the instrument), then taking out the central mirror, and turning it, so that the edge which was formerly uppermost may now be nearest the plane of the instrument; rectify its position, and again measure the distance of the two objects; half the difference between these two distances will be the error of the observed angle arising from the defect of parallelism of the central mirror. If the first distance exceeds the second, the error is subtractive, otherwise additive, the mirror being in its first position; but the contrary when in its second position. Thus, if the first distance was 119° 59′ 21′′, and the second 120° 0′ 39′′, the error would be 39′′, additive when the mirror was in its first position, subtractive for the second. The error for any other angle may be found by means of col. 2d Table XXXIV., when the inclination of the plane of the horizon glass to the axis of the telescope is 80°, by saying, As the tabular correction corresponding to 120° (= 4′ 5′′) is to the error of the glass 39′′, so is the tabular error for any other angle, as 85° (= 1′ 15′′), to the corresponding error of the glass 12′′. In this manner a table of errors may be made for all angles.*

The angle between the plane of the horizon glass and axis of the telescope produced being constant in all observations and adjustments of the sextant, no error can arise from the want of parallelism of its surfaces.

Verification of the parallelism of the surfaces of the colored glasses.

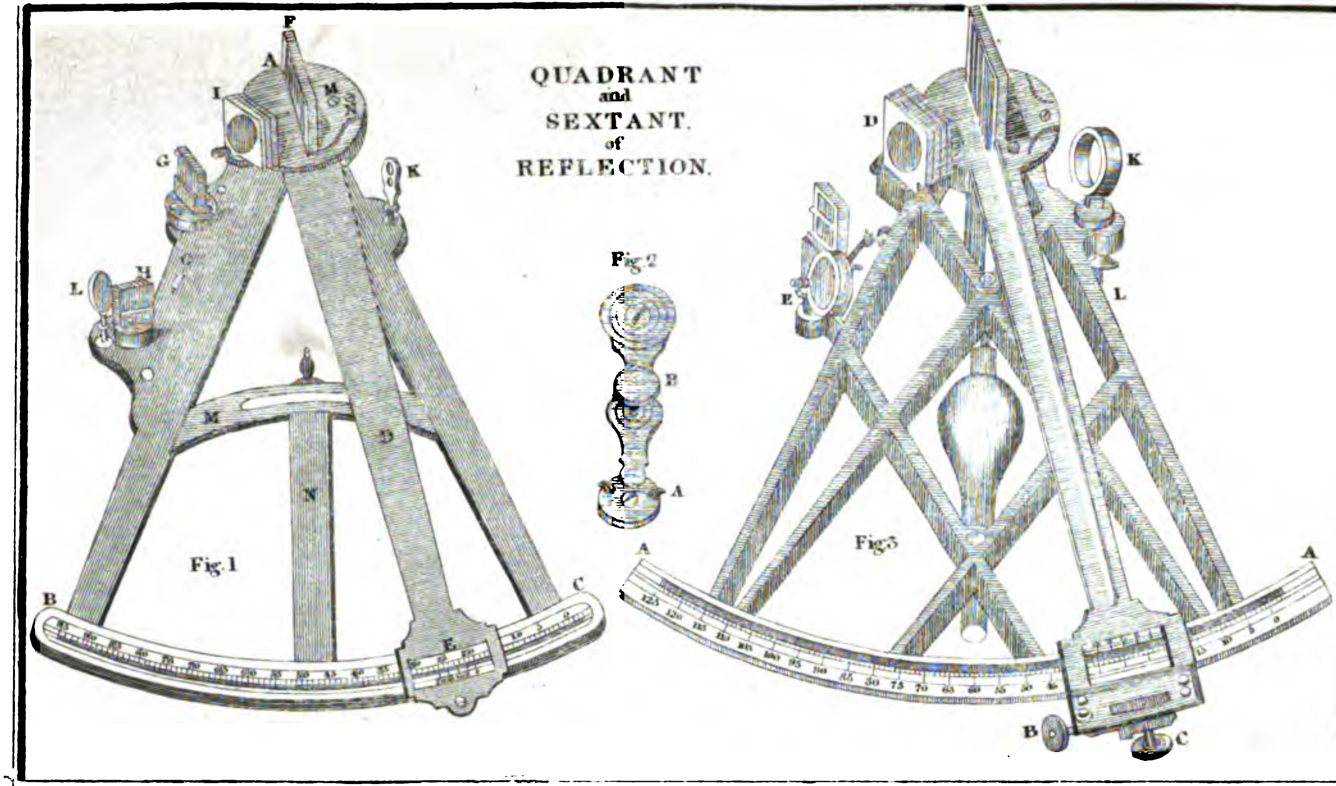
Turn down the glass at D which is to be examined, and another at E to defend the eye from the sun; direct the telescope to the sun, and move the index till its direct and reflected images coincide; then turn the dark glass at D so that the surface which was farthest from the horizon glass may now be nearest to it, and if the contact of the same two limbs be complete, the surfaces of this glass are parallel; but if they lap over or separate, the index must be moved to bring them again in contact; then half the arc passed over by the index will be the error arising from the want of parallelism of the glass at D. If a defect of this kind is found in any one of these colored glasses, it is best to avoid the use of it altogether.

---

* The method of calculating the above tabular numbers, when the angle of inclination of the telescope and horizon glass differs from 80°, is given in the explanation of Table XXXIV. prefixed to the tables.

Digitized by Google

Plate X.



Digitized by Google

Digitized by Google

DESCRIPTION AND USES OF THE CIRCLE OF REFLECTION.

The Circle of Reflection was invented by the celebrated Professor *Mayer*, of Groningen, and has since been greatly improved by the Chevalier *De Borda*, Mr. *Troughton*, and Mr. *Mendoza y Rios*. In its present improved state, it has a decided superiority over the sextant, in measuring the distance of the moon from the sun or a star, on account of its correcting, in a great measure, the errors arising from a faulty division of the limb, want of parallelism in the surfaces of the mirrors and colored glasses, and entirely avoiding the error which might arise in a sextant from the mirrors not being parallel when the index is on 0.

Figure 1, Plate X., represents the Circle of Reflection, as given by De Borda. In figure 2 is a section of the same instrument, marked with the same letters of reference as in figure 1. The principal parts of this instrument are, the circular limb LMV; the central index EF; the horizon index MD; the central glass or mirror A; the horizon glass or mirror B; the telescope GH; the colored glasses, figures 3, 4; the handle, figure 5; the ventelle, figure 6; and the adjusting tool, figure 7.

The *limb of the instrument* LMV is a complete circle of metal, and is connected with a perforated central plate by six radii; it is divided into 720°, because of the double reflection; each degree is generally divided into three equal parts, and the division is carried to minutes, or lower, by means of the verniers of the two indices.

The *two indices* are movable round the same axis, which passes exactly through the centre of the instrument; the central index EF carries the central mirror A; and the horizon index MD carries the telescope GH and the horizon mirror B; both indices are furnished with verniers and tangent screws at O and N.

The *central mirror* A is placed on the central index immediately above the centre of the instrument; the plane of this mirror makes an angle of about 30° with the middle line of the index, and is adjusted perpendicular to the plane of the instrument, by means of the screws placed on the back part of the frame of the mirror.

The *horizon glass* B is placed on the horizon index, near the limb, so as to interfere as little as possible with the rays proceeding from objects situated on the opposite side of that index with respect to the central mirror. The horizon glass is adjusted perpendicular to the plane of the instrument, in a similar manner to that of the horizon glass of a sextant; and in some circles, this mirror is movable about an axis perpendicular to the plane of the instrument; by this means the situation with respect to the telescope may be adjusted.

The *telescope* GH, attached to the other end of the horizon index, is an astronomical one, inverting the observed objects, and has two parallel wires in the common focus of the glasses, distant from each other between two and three degrees. These wires, at the time of observation, must be placed parallel to the plane of the instrument: to effect this, marks are made on the eye-piece, and on the tube at G, and by making them coincide, the wires may be brought to their proper position. The telescope may be raised or depressed by two screws, I, K, so as to be directed to any part of the horizon glass; and, by means of the graduations on the two standards, *i*, *k* (Fig. 2), the telescope may be rendered parallel to the plane of the instrument.

There are two sets of *colored glasses* (fig. 3, 4), each set usually containing four glasses of different shades; the glasses of the large set (fig. 4), which are placed before the central mirror at *a*, *a*, should have each about half the degree of shade with which the corresponding glasses (fig. 3) of the other set, placed at C, are tinged, because the rays from the luminous object pass twice through the colored glass placed before the central mirror, and only once through the other. The glasses placed at *a*, *a*, are kept tight in their places by small pressing screws at their ends, or by slides passing, in front, through perforations in the stems of their frames; when fixed for observation they make an angle of about 85° with the plane of the instrument; by this means, the

Digitized by Google

image from the colored glass is not reflected to the telescope. When the angle to be measured is between 5° and 35°, one of the large set is to be fixed at *a*, *a*; in other cases, one of the small set is to be placed in the socket C. The reason of using the large glass is this:—when the small glass is placed at C, it intercepts the direct light of the luminous object, in its passage towards the central mirror, if the object happens to be situated within the angular space included by the lines from the centre A, by the sides of the frame of the glass placed at C. This is avoided by using the large glasses.

The *handle* (fig. 5) is of wood, and is fixed to the back of the instrument immediately under the centre. By this it is held during the time of observation.

The *ventelle* (fig. 6) is used in terrestrial observations to diminish the light of the object seen directly, to render it equal in brightness to that of the object seen by reflection; this is performed by putting the ventelle in the socket D, and raising or depressing it till the objects appear of equal brightness.

There are two *adjusting tools*, of the form represented in figure 7; they are exactly of the same size, and their height is nearly equal to that of the central mirror; they may be used in adjusting the central mirror perpendicular to the plane of the instrument, and in making the axis of the telescope parallel to that plane.

The instrument, as we have now described it, is the same as it was left by De Borda. Mr. Troughton has since suggested the improvement of fixing to the horizon index the arc WSPR, and providing it with two sliding pieces U, X, in order to facilitate the fixing the indices at their proper angles with each other in taking successive observations. When the central and horizon glasses are parallel, the central index covers the space SP of the arc, and the spaces SW, PR, are each divided into degrees from S to W, and from P to R, and numbered 0 at S and P, and continued to 130° towards W and R. The use of this arc and sliding pieces will be explained hereafter.*

That ingenious mathematician and navigator, Mr. Mendoza y Rios, has further improved the circular instrument, by the substitution of a circular ring (moving round the centre of the instrument, over or adjacent to the limb TMV) for a vernier, instead of those attached to the indices by De Borda; and, by fixing this circular vernier alternately to each of the indices, it serves as a vernier for both, and, after any number of observations, gives the compound motion of both indices; and thus double the number of distances are obtained by this instrument, that can be obtained by De Borda's circle, with the same number of observations. Mr. Rios has also improved the form of the handle for holding the instrument. In theory, the instrument as improved by Mr. Rios appears to be superior to that of De Borda; but not having used one of the former kind, I cannot, from my own experience, decide whether it is so much superior in practice; but Mr. Rios says that he found it answered his expectations. As the method of taking the observation is nearly the same with both instruments, I shall confine myself to the explanation of the uses of De Borda's, from which the method of using the other will be easily discovered.

Adjustments of the circle of reflection.

Before entering upon an explanation of the adjustments of this instrument, it will be proper to premise that there are three different methods of observing the angular distance of two objects with this instrument, viz. (1) by what is called an observation to the right, (2) by an observation to the left, and (3) by a cross observation.

An observation to the right is that where the object whose image is to be reflected, and the central mirror, are on the same side of the telescope; *an observation to the left*, when the object to be reflected and the central mirror are on opposite sides of the telescope, which, in both cases, is supposed to be directed to the other object; and *a cross observation* is a combination of the fore-mentioned observations, the first being generally taken to the left, and the second to the right.

The adjustments of a circle consist in placing the mirrors perpendicular to the plane of the instrument, and in making the axis of the telescope parallel to that plane.

* Mr. Troughton suggested another alteration in the circle; but (as Mr. Rios justly observes) the instrument thus altered may be considered as a sextant, the limb of which is completed to the whole circumference. A circle of this description is usually furnished with three indices and verniers, by each of which every observation must be read off. This is very troublesome, particularly in the night. It is true that this method corrects, in a very great degree, the error of not having the index exactly on the centre, or that of not having an instrument perfectly circular; but errors of this kind in Borda's circle may be reduced in any ratio by taking a number of observations, and the error will in general be extremely small in taking a sufficient number to bring the index nearly to the point set out from so that, in those important points, I should, on the whole, prefer an instrument of Borda's construction.

Digitized by Google

These are all the adjustments necessary in measuring an angular distance by cross observations; but if one observation only be taken to the right, or to the left, it will be necessary to find the division on which the horizon index must be placed, to make the horizon glass parallel to the central glass, when the central index stands on 0 These adjustments are similar to those of a sextant; but a particular explanation of each will here be given.

To set the central glass perpendicular to the plane of the instrument.

This adjustment may be made by placing the eye in front of the central glass at L, a little above the plane of the instrument, and observing if the reflected image of that part of the limb nearest the eye appears to make one continued circular line with the parts of the limb towards T, seen to the right and left of the central glass; for, in this case, the glass is perpendicular to the plane of the instrument; otherwise it must be adjusted by means of the screws till the two images coincide.*

By examining this adjustment in different parts of the limb, it will be known if the limb be in the same plane. If any difference should be found, the central glass must be so fixed that the reflected image of the limb may appear as much above the direct image in some places as below it in others.

To set the horizon glass perpendicular to the plane of the instrument.

The central glass being previously adjusted, and the telescope directed to the line separating the silvered from the transparent part of the horizon glass, hold the instrument nearly vertical, and move either index till the direct and reflected image of the horizon, seen through the telescope, coincide; then incline the instrument till it is nearly horizontal, and, if the images do not separate, the horizon glass is perpendicular to the plane of the instrument; but if they do separate, the position of the glass must be rectified by means of the screws in its pedestal.

This adjustment may be also made by directing the sight through the telescope to any well-defined object; then if, by moving the central index, the reflected image passes exactly over the object seen directly, the glass is perpendicular; otherwise its position must be adjusted by means of the screws attached to the pedestal of the glass.

A planet, or star of the first magnitude, will be a good object for this purpose. If the sun is used, one of the colored glasses must be placed at C, and another at D.

To make the axis of the telescope parallel to the plane of the instrument.

The telescope may be raised or depressed by means of two screws attached to the standards *i*, *k* (fig. 2), and passing through two pieces of brass connected with the tube of the telescope. On each of these pieces is a mark or index, by which the telescope is to be adjusted; for, by bringing the indices to the same mark on each standard, the telescope will be parallel to the plane of the instrument.†

To find that division to which the horizon index must be placed to render the mirrors parallel when the central index is on 0.

Place the central index on 0; direct the telescope to the horizon glass, so that the line joining the silvered and transparent parts of that glass may appear in the middle of the telescope; hold the instrument vertically, and move the horizon index till the direct and reflected horizons agree, and the division shown by the horizon index will be that required.

This adjustment may also be made by measuring the diameter of the sun in

* When the instrument is furnished with adjusting tools, this adjustment may be made in the following manner:—Set the two tools on opposite parts of the limb at T and L; place the eye at *e*, at nearly the same height as the upper edge of the tools, so that part of the tool at T may be hid by the central glass; move the central index till the reflected image of the tool nearest the eye appears in the central glass at the side of the other tool seen directly; then, if the upper edges of the tools are apparently in the same straight line, the central glass is perpendicular to the plane of the instrument; otherwise its position must be adjusted by the screws at the back of the frame.

† If you suspect that the marks on the standards are inaccurate, you may examine them in the following manner:—Lay the circle horizontally on a table; place the two adjusting tools on opposite parts of the limb, at T and L; and at about 12 or 15 feet distance let a well-defined mark be placed, so as to be in the same straight line with the tops of the tools; then raise or lower the telescope till the mark is apparently in the middle between the two wires; then the axis of the telescope will be parallel to the plane of the instrument, and the difference (if any) between the divisions pointed out by the indices on the graduation of the standards *i*, *k* (fig. 2), will be the error of the indices, and, this being known it will be easy, in future adjustments, to make allowance for it.

Digitized by Google

contrary directions; thus, the central index being fixed on 0, place a dark glass at C, and another at D; direct the telescope (through the transparent part of the horizon glass) to the sun; and move the horizon index till his reflected image appear in the telescope; bring the upper edge of the direct image to coincide with the lower of the other, and note the angle shown by the index; then, by moving the horizon index, bring the lower edge of the direct image to coincide with the upper edge of the reflected one, and note also the angle pointed out by the index; half the sum of these two angles will be the point of the limb where the horizon index must be placed to render the mirrors parallel. Thus, if the index, in the first observation, is on 473° 30′, and, in the second, on 474° 34′, the half sum of the two, 474° 2′, will be the point where the horizon index must be placed to make the mirrors parallel.

These are all the adjustments necessary to be made preparatory to measuring any angular distance.* When the angle is measured by cross observations, the error arising from the want of parallelism of the surfaces of the mirrors and screens, will in general be very small; however, the method of verifying those glasses, and making allowance for any error in them, will be given hereafter.

To observe the meridian altitude of any celestial object, either by an observation to the right or to the left.

The method of observing the meridian altitude of an object with a circle, is exactly similar to that with a quadrant or sextant. The central index must be fixed on 0, and the horizon index on the point which renders the two mirrors parallel; then the altitude may be taken either by an observation to the right or to the left; but the former method, in which the large colored glasses are not necessary, is in general to be preferred, because these large glasses are more liable to cause an error in the observation than the small ones.

If an observation to the right is to be taken, a small dark glass must be placed at C, if the object be bright; then hold the instrument in the right hand, in a vertical position, move the central index, according to the order of the divisions of the limb, till the reflected image of the object, seen in the telescope, nearly touches the direct image of the horizon; tighten the index by the screw at the back of the instrument; make the contact complete in the middle between the parallel wires of the telescope, by the tangent screw, and by sweeping, exactly in the same manner as when observing with a quadrant, and the central index will point out the altitude of the object.

If an observation to the left is taken, and the object be bright, a large dark glass must be placed at *a*, *a*, if the altitude be between 5° and 35°, otherwise a small glass at C hold the instrument in the left hand, in a vertical position; move the central index contrary to the order of the divisions, and bring the reflected image in contact with the horizon as above; the angle shown by the central index, being subtracted from 720°, will be the sought altitude.

In both these methods of observing the meridian altitude of an object, the circle, the radius of which is only five inches, will hardly be so accurate as a good sextant of a larger radius; but, by the help of a well-regulated watch, the meridian altitude may be obtained, by the circle, to a much greater degree of accuracy than by a sextant, by observing in the following manner:—A few minutes before the object passes the meridian, begin to observe the altitude by cross observations (in the manner to be described in the next article), and note the time of each observation by the watch; continue to observe till a few minutes after the object has passed the meridian; then the angles shown by the central index, being divided by the whole number of observations, will give the approximate meridian altitude; the correction to be applied to it to obtain the true meridian altitude, may be found by means of Tables XXXII. and XXXIII., by a method which will be explained hereafter, when treating of finding the latitude by a single altitude of the sun.

In this article, the meridian altitude only has been spoken of, though it is evident

* In some instruments, there is an adjustment of the horizon glass, to place it at its proper angle with the axis of the telescope; if an adjustment of this kind is necessary, it ought to be made before the other adjustments, in such manner that if a colored glass be fixed at C, none of the rays from the central glass can be reflected to the telescope from the horizon glass, without passing the colored glass. To effect this, the *ventelle* must be placed at D, and lowered so as to intercept the direct light entirely; then place the colored glass at C, and direct the telescope to the silvered part of the horizon glass; move the central index, and if no uncolored images appear (reflected from the central glass), but all have the same tinge as that of the colored glass used, the horizon glass is in its proper position; otherwise it must be turned on its axis till the uncolored images disappear.

Digitized by Google

that the method is applicable to an object not on the meridian; but, in this case, the cross observations, which give to the circle all its advantages, may be used, and the mean of the altitudes taken instead of a single altitude. This method is peculiarly adapted to the taking of altitudes for regulating a watch; for this reason it will be particularly explained in the following article:—

To take altitudes of the sun, or any celestial object, by cross observations, for regulating a watch.

Fix the central index on 0, and if the object be bright, and the altitude between 5° and 35°, place a large colored glass before the central glass at *a*, *a*, otherwise a small one at C; hold the instrument in the left hand, in a vertical position: move the horizon index till the image of the reflected object be brought in complete contact with the horizon, in the middle between the two parallel wires of the telescope, as directed in the preceding article, and note the time of observation by the watch; then fasten the horizon index; hold the instrument in the right hand, in a vertical position; move the central index according to the order of the divisions, till the reflected image be again brought into complete contact with the horizon * as above, and note the time of observation. Then half the sum of the times, and half the angle shown by the index, will be a mean time, and a mean altitude corresponding thereto.

Times of obs.			*Angle.*
4h.	20m.	0s.	
4	21	10	
4	22	15	
4	23	0	
4	24	45	
4	25	30	
6) 26	16	40	6) 60° 24′
4	22	47	10 4

If greater accuracy be required, the observation must be repeated, setting out from the points where the indices then are, and observing in the same manner by moving first the horizon index, then the central one; continue taking as many of these cross observations as are judged necessary, and note the times of each observation; then the sum of the times, divided by the whole number of observations, will be a mean time; and the angle shown by the central index, divided by the number of observations, will be a mean altitude corresponding thereto. Thus, if six † observations were taken, and the times noted as in the adjoined table, the angle shown by the index being 60° 24′ the mean time would be obtained by dividing the sum of the times, 26h. 16m. 40s., by 6, and the mean altitude by dividing 60° 24′ by 6; therefore the mean time would be 4h. 22m. 47s., and the mean altitude corresponding 10° 4′.

To measure the distance between the sun and moon by a circular instrument.

The instrument being well adjusted, fix the central index on 0, and, if the object be bright, place a small dark glass at C; hold the instrument so that its plane may be directed to the objects with its face downwards when the sun is to the right of the moon; otherwise, with its face upwards; direct the sight through the telescope to the moon; move the horizon index, according to the order of the divisions of the limb, till the reflected image of the sun appears in the telescope, and the nearest limbs of the sun and moon are almost in contact; fasten the index, and make the coincidence of the limbs perfect, in the middle between the two parallel wires of the telescope, by means of the tangent screw of the horizon glass, and note the time of observation;

* The arc described on the limb by the central index, will be equal to twice the altitude of the object, or twice the angle passed over by the other index: if more cross observations be taken, each of the indices, when moved, will describe an arc equal to double the altitude of the object; the same is to be observed in measuring any other angular distance. If the instrument is furnished with the arc WSR, and sliding pieces U, X, you must bring the slide X to the central index, after taking the first observation to the left, and place the slide U at the same degree, on the arc SW, that X is on the arc PR; then. in the next observation, the central index is to be brought to touch the slide U; in the next observation to the left, the slide X is to be brought to the central index, and so on for the other observations. Thus, by means of the slides, the indices may be placed at nearly their proper angles with each other at the beginning of the observation, which will save considerable time. After being thus fixed, the contact must be completed by means of the tangent screw of the index, which is to be moved.

† The number 6 is a convenient number to use, because the remainder of the division of the hours by 6 gives the first figure of the minutes; and the remainder of the division of the minutes by 6 gives the first figure of the seconds. Thus, in the above example, in dividing 26h. by 6, we get 4h., and the remainder 2 is set down immediately for the first figure of the minutes; the second figure of the minutes is the quotient 2, found by dividing 16m. by 6, and the remainder 4 of this last division is the first figure of the seconds. We may remark that, as the term 4h. 20m. is common to all the 6 observations, it may be neglected; then adding the minutes in the column of units, and the seconds, the sum becomes 16m. 40s dividing this by 6 gives 2m. 47s., to be connected with 4h. 20m., making, as above, 4h. 22m 47s

Digitized by Google

then invert the instrument, and move the central index, according to the order of the divisions of the limb, by a quantity equal to twice the arc passed over by the horizon index (or twice the distance of the sun and moon);* direct the plane of the instrument to the objects; look directly at the moon, and the sun will be seen in the field of the telescope; fasten the central index, and make the contact of their nearest limbs complete, in the middle between the two parallel wires of the telescope, by means of the tangent screw of the central index, and note the time of observation; then half the arc shown by the central index will be the distance of the nearest limbs of the sun and moon, and half the sum of the times will be the mean time of observation.

Having finished these two observations, two others may be taken in the same manner, setting out from the points where the indices then are, and moving first the horizon index, then the central index: proceed thus till as many observations as are judged necessary be taken, always observing *that the number of them be even;* then the angle shown by the central index (or that angle increased by 720° or 1440°, &c., if the index has been moved once or twice, &c., round the limb), being divided by the whole number of observations, will give the mean distance; and the sum of all the times, divided in like manner, will be the mean time of observation.

To measure the distance between the moon and star by a circular instrument.

Fix the central index on 0, and, if the moon be bright, and the distance between 5° and 35°, place a large green glass before the central mirror at *a*, *a*, otherwise a small one at C; hold the instrument so that its plane may be directed to the objects with its face downwards when the moon is to the right of the star, otherwise with its face upwards; direct the sight through the telescope to the star; move the horizon index, according to the order of the divisions of the limb, till the reflected image of the moon appears in the telescope, and the enlightened limb of the moon be nearly in contact with the star; fasten the index, and make the coincidence perfect, in the middle between the parallel wires of the telescope, by means of the tangent screw belonging to that index, and note the time of observation; then invert the instrument, and move the central index, according to the order of the divisions of the limb, by a quantity equal to twice the arc passed over by the horizon index;* direct the plane of the instrument to the objects; look directly at the star, and the moon will be seen in the field of the telescope; fasten the central index, and make the contact of the enlightened limb of the moon and the star complete, in the middle between the two parallel wires of the telescope, by means of the tangent screw of that index, and note the time; then half the arc shown by the central index will be the distance of the star from the enlightened limb of the moon, and half the sum of the times will be the mean time of observation; these two observations being completed, others may be taken in the same manner, according to the directions above given for measuring the distance of the sun from the moon.

In continuing to take these cross observations by a circle furnished with the arc WSR, and slides U, X, it will be very easy to bring the reflected image into the field of the telescope; but if the instrument is not thus furnished, it will be often difficult to bring the image into the field of the telescope, and much time will be lost, and the observations rendered tedious by that means; to remedy this, a small table of the angles, at which each index should be placed, ought to be made before beginning the observation; this table is easily formed, as follows:—Find roughly, according to the directions heretofore given, the point at which the horizon glass must be placed to be parallel to the central glass, when the central index is on 0; then find what point of the arc the horizon index stands upon, after measuring the first distance, as directed above; the difference between these two points will be the angular distance of the objects; the double of this distance, being successively added to 0°, and to the angle pointed out by the horizon index after the first observation, will give the points of the arc where the indices must be placed at the 2d, 3d, 4th, &c. observations. Thus, if the point of parallelism is 471°, and the point where the horizon index is at the first observation is 525°, the difference, or 54°, will be the angular distance; the double of this, or 108°, being added to 525°, gives 633°, which is the point of the arc where that index must be placed at the third observation; 633° added to 108° gives 741° or 21° (because the divisions recommence at 720°), which is the point where the index must be placed at the fifth observation, &c., as in the adjoined table. The central index being at

Central Index.	*Horizon Index.*
0°	525
108	633
216	21
324	129
432	237
540	&c.
&c.	

* This may be done expeditiously by means of the slides U, X, as is explained in the preceding note.

Digitized by Google

first on 0°, after the second observation it will be on 108°, at the fourth on 108° + 108° = 216°, at the sixth on 216° + 108° = 324°, &c. Thus, by constantly adding 108°, or twice the distance of the objects, the angles at which the indices must be placed will be obtained; and by fixing them at these angles, the reflected image will be brought into the field of view without any trouble.*

Having explained the methods of adjusting and using the circle of reflection, it remains to show how to calculate the error arising from not observing the contact of the objects in the middle between the parallel wires of the telescope, and also to estimate the errors arising from the want of parallelism of the mirrors and colored glasses. These verifications are much more necessary in a sextant than in a circle, and they may be in general neglected in a circle.

To estimate the error arising from not observing the contact of the objects in the middle between the parallel wires of the telescope.

To estimate this error, it is necessary to know the angular distance of the wires of the telescope, which may be thus determined:—

Turn round the eye-piece of the telescope till the wires are perpendicular to the plane of the instrument, and put the central index on 0; direct the telescope to any well-defined object, at least 12 feet distant, and move the horizon index till the direct and reflected image of the object coincide; then make one of the wires coincide with the object, and turn the central index till the reflected image of the object coincides with the other wire—and the arc passed over by that index, will be the angular distance between the wires. This angle being obtained, the observer must, by means of it, estimate, at each observation, how much the place where the contact is observed is elevated above, or depressed below, the plane passing through the eye and the middle line between the two parallel wires of the telescope: the correction in Table XXXV., corresponding to this angle, is to be subtracted from the observed angular distance of the objects: thus, if the distance between the wires is 2°, one of them will be elevated above that plane 1°, and the other depressed below it, by the same quantity; if, in taking an observation, the point of contact is estimated to be one third part of the distance from the middle towards either wire, the angle of elevation or depression will be one third part of 1°, or 20′; and if the observed distance is 120°, the correction in Table XXXV. will be 12″, subtractive from the observed distance.

The correction for each observed distance being ascertained, in the above manner, the sum of them must be subtracted from the whole angle shown by the central index, and the remainder, divided by the whole number of observations, will be the mean distance.

Verification of the parallelism of the surfaces of the central mirror.

This verification is to be made ashore, by observing the angular distance of two well-defined objects, whose distance exceeds 90° or 100°, having previously well adjusted the instrument: after taking several cross observations, and finding the mean distance, take out the central mirror, and turn it so that the edge which was formerly uppermost may now be nearest the plane of the instrument; rectify its position, and take an equal number of cross observations of the angular distance of the same two objects; half the difference between the mean of these and that of the former, will be the error of the observed angle, arising from the defect of parallelism of the central mirror. If the first mean exceeds the second, the error is subtractive, otherwise additive, the mirror being in its first position; but the contrary when in its second position. Thus, if 10 observations are taken at each operation, and in the first the angle shown by the index is 1199° 53½′, and in the second 1200° 6½′, by dividing by 10 the mean angles are found to be 119° 59′ 21″ and 120° 0′ 39″, and their difference is 78″; the half of it, or 39″, is the error of the mirror, additive when it is in its first position, subtractive in the second. The error for any other angle may be found by Col. 4, Table XXXIV., when the inclination of the plane of the horizon glass to the axis of the telescope is 80°, by saying, As the tabular error corresponding to 120°, that is, 1′ 30″, is to the error found in the glass 39″, so is the tabular error for any

---

* If the distance of the object varies during the observation, these angles will require correction as you proceed with the observations. Thus, if the distance was increasing, and at the sixth observation it was found that the central index was on 326° instead of 324°, the increase being 2°, you must add 2° to the rest of the numbers in the table, and place the horizon index, at the seventh observation, on 29° + 2° = 131°, and the central index, at the eighth observation, at 432° + 2° = 434°, &c.

Digitized by Google

other angle 85°, which is 0′ 28″, to the error of the glass corresponding 12″; and in this manner a table of errors may be made, not only for the cross observations, but also for observations to the right or to the left.*

It may be remarked that the errors are much less in the cross observations than in the observations to the right, which are those made with a quadrant or sextant; so that the circle has, in this respect, greatly the advantage of those instruments.

The angle between the plane of the horizon glass and axis of the telescope produced being nearly the same in all observations and adjustments of the circle, no sensible error can arise from the want of parallelism in the surfaces of that glass.

Verification of the parallelism of the colored glasses.

Place one of the dark-colored glasses at C, and another at D; fix the central index at 0, direct the telescope to the sun, and move the horizon index till the limbs of the direct and reflected image coincide; then turn the dark glass placed at C, so that the surface which was farthest from the horizon glass may now be nearest to it, and if the contact of the same two limbs be complete, the surfaces of the glass placed at C are parallel; but if the limbs lap over or separate, the central index must be moved to bring them again in contact; then half the arc passed over by that index will be the error arising from the want of parallelism of the glass C. If great accuracy is required, the operation may be repeated by setting out from the point where the indices then are, and taking 4 or 6, &c., observations; then the arc passed over by the central index, being divided by 4, 6, &c., will be the sought error. The other small glass may be verified in the same manner; and, by placing one of the larger glasses before the central index at *a*, *a*, and one of the smaller ones at D, the former may be verified as above. The green glasses may be verified by observing the diameter of the full moon, or by some bright terrestrial object.

It may be remarked, as one of the greatest advantages of the circle, that, in measuring an angle by the cross observations, no error can arise from the want of parallelism in the surfaces of the smaller dark glasses; for if these glasses give too great an angle by an observation to the right, they will give too little by the same quantity by an observation to the left. It is not so with the large glasses placed at *a*, *a*, because the incidence of the rays on these glasses is more oblique in one observation than in the other, so that the errors do not wholly balance each other; however, as these glasses are used only in measuring angles less than 35°, where the errors are nearly the same as if the incidence of the rays were perpendicular, the errors of these glasses will also nearly compensate each other in the cross observations; and if such observations only are used, it will be unnecessary to verify the dark glasses. Even when taking observations to the right, or observations to the left, the error of the dark glasses will be destroyed, if the glass is turned at each observation, and the number of observations is even; but there are some cases in which an angle can only be measured by one observation; then it will be necessary to allow for the error of the dark glass, if the distance is required to be found within a few seconds.

* If the inclination of the plane of the horizon glass and the axis of the telescope differ from 80°, you may find the tabular numbers by the method given in the explanation of Table XXXIV. affixed to the tables

Plate XI

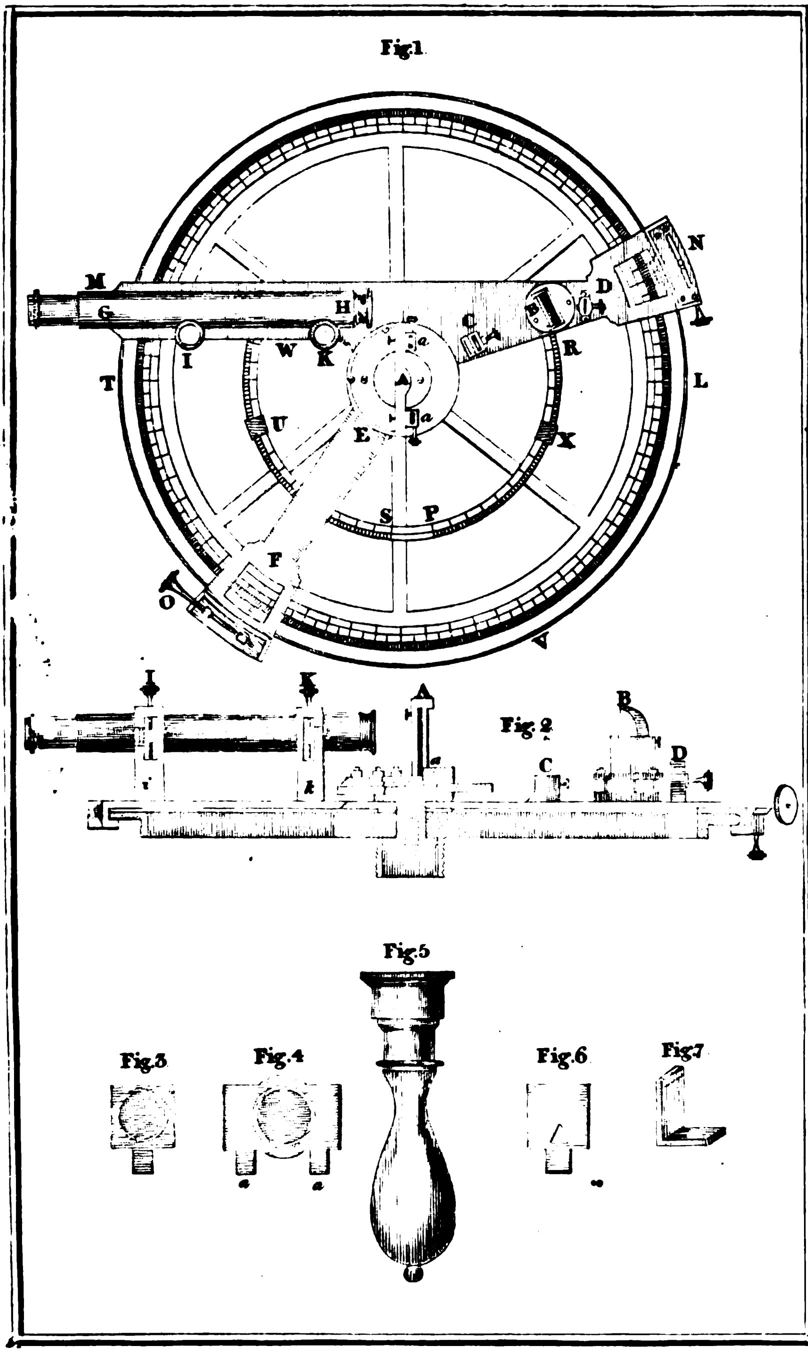


Fig.1
M
G
H
I
W
K
T
U
E
S
P
X
R
L
N
D
B
C
F
O
A
a
Fig. 2
I
K
A
B
C
D
a
k
Fig.3
Fig.4
a
a
Fig.5
Fig.6
Fig.7

Digitized by Google

DESCRIPTION AND USE OF A PORTABLE TRANSIT INSTRUMENT.

A Transit Instrument is of no service on board of a vessel, but is much used ashore, in seaports, for regulating chronometers for sea voyages, and in making observations to determine the longitude. We have, therefore, thought it would be useful to give a brief description of it, with the methods of adjustment; particularly as it may be considered as a valuable accession to the apparatus of a good navigator, who, while remaining in port a few days, can, by means of it, adjust and fix the rate of going of his chronometer with ease and accuracy, and also obtain the best data for determining the longitude of the place, by observing the times of the moon's transit or passage over the meridian.

The figure in Plate XI., figure 1, represents this instrument, according to the usual construction of Mr. Troughton, with a telescope of about twenty inches foca length. The telescope tube AA is in two parts, connected together by a sphere B which also receives the larger ends of the two axes C, C, placed at right angles to the direction of the telescope, and forming the horizontal axis. This axis terminates in two cylindrical pivots, which rest in Y's fixed at the upper end of the vertical standards D, D. One of the Y's possesses a small motion in azimuth, communicated by turning the azimuth screw *a*. In these Y's, the telescope turns upon its pivots; but, that it may move in a vertical circle, the pivots must be precisely on a level with each other; otherwise the telescope will revolve in a plane oblique to the horizon, instead of being perpendicular to it. The levelling of the axis, as it is called, is therefore one of the most important adjustments of the instrument, and is effected by the aid of a spirit level E, which is made, for this purpose, to stride across the telescope, and rest on two pivots.

The standards DD are fixed by screws upon a brass circle F, which rests on three screws *b*, *c*, *d*, forming the feet of the instrument, by the motion of which the operation of levelling is performed. The two oblique braces GG are for the purpose of steadying the supports, it being essential for the telescope to have not only a free but a steady motion. On the extremity of one of the pivots, which extends beyond its Y, is fixed a circle H, which turns with the axis, while the double vernier, *ee*, remains stationary in a horizontal position, and shows the altitude to which the telescope is elevated. The verniers are set horizontal by means of a spirit level *f*, which is attached to them, and they are fixed in their position by an arm of brass *g*, clamped to the supports by a screw *h*; the whole of this apparatus is movable with the telescope, and, when the axis is reversed, can be attached, in the same manner, to the opposite standard.

Near the eye-end, and in the principal focus of the telescope, is placed the *diaphragm*, or *wire-plate*, which has five vertical and two horizontal wires. The centre vertical wire ought to be fixed in the optical axis of the telescope, and perpendicular to a line drawn through the pivots of the axis. It will be evident, upon consideration, that these wires are rendered visible, in the day-time, by the rays of light passing down the telescope to the eye; but at night, except when a very luminous object (as the moon) is observed, they cannot be seen. Their illumination is therefore effected by piercing one of the pivots, and admitting the light of a lamp fixed on the top of one of the standards, as shown at I. This light is directed to the wires by a reflector placed diagonally in the sphere B. The reflector, having a large hole in its centre, does not interfere with the rays passing down the telescope from the object, and thus the observer sees distinctly the wires and the object at the same time. When, however, the object is very faint (as a small star), the light from the lamp would overpower its feeble rays. To remedy this inconvenience, the lamp is so constructed that, by turning a screw at its back, or inclining the opening of the lantern, more or less light may be admitted to the telescope, to suit the circumstances of the case.

The telescope is furnished with a diagonal eye-piece, by which stars near the zenith may be observed without inconvenience.

Digitized by Google

Adjustments of a transit instrument.

In fixing the instrument, it should be so placed that the telescope, when level, should point north and south as near as can possibly be ascertained. This can at first be done only in an approximate manner, as the correct determination of the meridian can only be obtained by observation, after the other adjustments are completed.

To adjust the line of collimation.

The first adjustment is that of the line of collimation, or line of sight. Direct the telescope to some distant, well-defined object (the more distant the better), and bisect it with the middle of the central wire; then lift the telescope very carefully out of its angular bearings or Y's, and replace it with the axis reversed; point the telescope again to the same object, and, if it be still bisected, the collimation adjustment is correct; if not, move the wires one half the error, by turning the small screws which hold the diaphragm near the eye-end of the telescope, and the adjustment will be accomplished; but as half the deviation may not be correctly estimated in moving the wires, it becomes necessary to verify the adjustment by moving the telescope the other half, which is done by turning the azimuth screw *a;* this gives the small azimuthal motion to the Y, before spoken of, and consequently to the pivot of the axis which it carries. Having thus again bisected the object, reverse the axis as before, and, if half the error was correctly estimated, the object will be bisected upon the telescope being directed to it; if not quite correct, the operation of reversing and correcting half the error, in the same manner, must be gone through again, until, by successive approximations, the object is found to be bisected in both positions of the axis; the adjustment will then be perfect.

To adjust the wires in the telescope.

It is desirable that the central or middle wire (as it is usually termed), should be truly vertical, as we shall then have the power of observing the transit of a star on any part of it, as well as the centre. We may ascertain whether it is so, by elevating and depressing the telescope; for when directed to a distant object, if it is bisected by every part of the wire, the wire is vertical; if otherwise, it should be adjusted by turning the inner tube carrying the wire-plate until the above test of its being vertical be obtained, or else care must be taken that observations are made near the centre only. The other vertical wires are placed, by the maker, equidistant from each other and parallel to the middle one; therefore, when the middle one is adjusted, the others are so too; he also places the two transverse wires at right angles to the vertical middle wire. These adjustments are always performed by the maker, and are but little liable to derangement. When, however, they happen to get out of order, and the observer wishes to correct them, it is done by loosening the screws which hold the eye-end of the telescope in its place, and turning the end round a small quantity, by the hand, until the error is removed. But this operation requires very delicate handling, as it is liable to remove the wires from the focus of the object-glass.

To fix the axes or arms, upon which the telescope revolves, in a horizontal position.

The axes on which the telescope turns, must then be set horizontal. To do this, apply the level to the pivots; bring the air-bubble to the centre of the glass tube, by turning the foot-screw *b*, which raises or lowers that end of the axis, and consequently the level resting upon it; then reverse the level, by turning it end for end, and, if the air-bubble still remain central, the axes will be horizontal; but if not, half the deviation must be corrected by the foot-screw *b*, and the other half by turning the small screw *i*, at one end of the level, which raises or lowers the glass tube (containing the air-bubble) relative to its supports, which rest upon the pivots. *This, like most of the adjustments, frequently requires several repetitions before it is accomplished, on account of the difficulty of estimating exactly half the error.*

This adjustment may also be made by means of the polar star; first by observing directly its transit over any one of the vertical wires of the telescope, and immediately afterwards observing the reflected image of the same star from a basin of quicksilver. For if the star appear on the same wire, the axis is properly adjusted; if not, you must bring the wire half way towards it by the small screw *i*, and then, by the azimuth screw *a*, bring it upon the wire again. This being completed, you must, as soon

Digitized by Google

as possible, look directly towards the star, and if it appear on the same wire, the adjustment is accurate; if not, repeat the operation till it is so; observing that the motion of the pole-star is so very slow, that it will not be sensibly altered in the interval of taking its transit directly and by reflection. The farther, however, you observe the star from the meridian, the more accurate will the observation be, since the motion of the star in a direction parallel to the horizon will then be the least; and when it is at its greatest azimuth, the horizontal motion is nothing.

To fix the instrument so that the line of collimation of the telescope may move accurately in the plane of the meridian.

Having set the axis, on which the telescope turns, parallel to the horizon, and proved the correct position of the central wire, or line of collimation, making it describe a vertical great circle, perpendicular to the axis, we must, in the last place, fix the instrument so that this vertical circle may be the meridian of the place of observation.

We have supposed the instrument to be nearly in the meridian. It may be so placed, with a great degree of accuracy, at the very first operation, by means of a well-regulated * and accurate time-keeper, by which we can determine very nearly the exact instant of the transit of the pole-star over the meridian, either above or below the pole. A few minutes before the time of the transit, we must direct the telescope towards the star, and, by turning the azimuth screw *a*, bring the star upon the middle wire of the telescope. The apparent motion of this star is so very slow, that we can, by a very small and gentle motion of the azimuth screw *a*, keep the star constantly bisected on the middle vertical wire of the telescope, till the moment of this transit, as indicated by the time-keeper, has arrived; then the instrument will be very nearly in the plane of the meridian, and the final corrections must be made in the following manner:—

First Method. Make the observations of the transits of the pole-star, above and below the pole, at three successive transits, and note the times of observation by an accurate time-keeper. Then, if the interval of time between the first and second transits is equal to the interval between the second and third transits, the instrument will be truly fixed in the plane of the meridian. In this case, each of the intervals will be equal to 12 hours, sideral time, corresponding nearly to $11^h\ 58^m\ 2^s$, as shown by an accurate chronometer, regulated to mean solar time. † It is very important, in this operation, that the rate of the time-keeper should be perfectly uniform during both intervals; but it is not necessary that its rate or regulation should be previously known. For, in the preceding example, if the time-keeper move too fast for mean solar time, and gain, for example, 10^s in each of the above intervals, making them equal to $11^h\ 58^m\ 12^s$ by the time-keeper, their equality would prove the accuracy of the adjustment to the plane of the meridian, with the same degree of certainty as if the time-keeper were regulated to mean solar or sideral time. However, it is much more convenient to have it well regulated.

Suppose, now, that the intervals, instead of being equal to each other, are found to differ. In this case, the instrument is not placed accurately in the plane of the meridian ZM*m*H (Plate XI. fig. 2, 3), but the motion of the telescope is in some vertical circle, as ZS*s*T, which cuts the horizon in the point T, situated to the west of the meridian H, in figure 2, or to the east, in figure 3; the distance from the meridian being measured on the horizon by the arc of azimuth HT. If we now suppose that MW*m*E is the small circle described by the star in its diurnal motion, M will be the place of the star at its upper transit over the meridian, and *m* its place at the lower transit, when well adjusted; but when the vertical motion of the telescope is in the vertical circle ZS*s*T, the upper observed transit will be at S, and the lower observed transit at *s*; the observed intervals of times being proportional to the arcs SW*s*, *s*ES. Now, it is evident, from the inspection of figures 2, 3,

* This regulation can be made by equal altitudes of the sun, observed with a sextant; or by a single altitude, when the latitude of the place is known; or by similar observations with a known star. The method of obtaining the time from such observations, will be explained hereafter.

† If the sun be supposed to move uniformly in the plane of the equator, the interval of two successive transits of the sun over the upper meridian, will be equal to 24 hours, mean solar time, and it is for this mean solar time that chronometers are usually adjusted. The interval between two successive transits of a fixed star over the same meridian, is very nearly equal to $23^h\ 56^m\ 4^s$, mean solar time; but it is found very convenient, in many astronomical and nautical calculations, to divide it into 24 hours, which are called hours of sideral time, and they are divided, as usual, into minutes and seconds. We have given, in our collection of tables, two tables for facilitating the reduction of the one of these times to the other

Digitized by Google

that the deviation is always towards that side of the meridian where the least interval is observed; as, for example, in figure 2, where the telescope describes the vertical circle ZSsT, to the west of the meridian, the western interval SW*s* is the least. The correction of this adjustment is made by means of a slight motion of the azimuth screw *a*; and the quantity of this motion depends on the difference of the two intervals. Suppose, for example, that one of the intervals is $11^h\ 58^m\ 2^s$, and the other $11^h\ 58^m\ 22^s$, which differ 20 seconds of time; the half-difference, 10 seconds, represents the time required by the star to pass over both the small arcs MS, *sm*; and, in the case of the pole-star, where the polar distance PM, or P*m*, is very small, the arcs MS, *sm*, are very nearly equal to each other, so that each of these arcs will be described in about one half of 10^s, or 5^s; or, in other words, *the time required to describe the arc* MS, *or* sm, *is very nearly equal to one quarter part of the difference between the two intervals*, which, in the present example, is $\frac{1}{4} \times 20^s = 5^s$. To correct this, we must watch the pole-star, as it approaches towards the lower transit *s*, if the deviation be to the west of the meridian, or as it approaches towards the upper transit S, if the deviation be to the east of the meridian; and, the moment the star is bisected by the middle wire of the telescope, we must begin to count these five seconds of time, and, by a very gentle motion of the azimuth screw *a*, keep the star constantly bisected by the wire until the expiration of the time of 5 seconds, or the quarter of the difference of the intervals. Then, if every part of the operation has been done accurately, and the time-keeper be perfectly correct, the instrument will be accurately adjusted in the plane of the meridian; but as this is one of the most important and delicate adjustments, it will be best to repeat again the observations of the three transits, to ascertain whether the first and second intervals of the successive transits are equal; and, if a slight difference should still be found, it must be corrected by repeating the operation in the manner we have already explained.

This method of adjusting the transit instrument (by means of the pole-star) is preferable to any other whatever. Delambre, who had much practical experience, says there is no advantage in using two stars; and that, with a single star, the preference is to be given to the pole-star; after this he recommends the stars δ, β, γ, of the Little Bear, and γ Cephei. These stars being more distant from the pole, it may become necessary to make a small correction in the quarter part of the difference of the intervals, to correct for the difference of the arcs SM, *sm*. This correction is made by means of the Table A, page 151, which gives the correction for the pole-star, and for other stars where polar distance is less than 40°, supposing the difference of the two intervals to be 1000 seconds of time. Thus, if the polar distance of the star be 20°, and the latitude 42°, the tabular correction is 82^s, which is to be applied to one quarter part of the assumed difference of the intervals, 1000^s, that is, 250^s, making $250^s + 82^s = 332^s$ for the distance of the star from the meridian, at the time of the lower transit, and $250^s - 82^s = 168^s$ for the distance of the star from the meridian at the upper transit. These times, 332^s, 168^s, must be reduced in the same ratio as the actual difference of the two intervals bears to the tabular difference 1000^s. Thus, if the observed difference of the two intervals were 205^s, instead of 1000^s, you must say, As 1000^s is to 205^s, so is 332^s to 68^s, and so is 168^s to 34^s, so that the correction to be applied to the lower transit is 68^s, and to the upper transit 34^s. Therefore, if the star be approaching towards the meridian at the time of the lower transit, you must proceed according to the former direction relative to the pole star, and keep the star constantly bisected by the middle wire of the telescope, by a slight and gentle motion of the azimuth screw *a*, from the time of its first transit by that wire, till you have counted 68^s by the time-keeper. But if the star be approaching towards the meridian at the upper transit, you must adjust the instrument by means of the next upper transit, making an allowance of 34^s for the distance from the meridian, and keeping the star constantly bisected, from the time of its transit by the middle wire, by means of the azimuth screw *a*, until the termination of the time of 34^s.

Before closing our remarks on this method of adjustment, we may observe, that if the angular value of one revolution of the azimuth screw be known, or the instrument possess an azimuth circle, by which the motion of the telescope may be accurately estimated, we may correct the adjustment by estimating the correction in azimuth by means of Table B, where the variations of azimuth, in seconds of a degree, are given for a supposed variation of 1000 seconds in the difference of the two intervals. Thus in the preceding example, where the polar distance of the star is 20°, latitude 42° difference of the two intervals 205^s; the tabular correction for 1000^s (difference of the two intervals) being $30'\ 42''$, we have $1000^s : 205^s :: 30'\ 42'' : 6'\ 18''$; therefore the correction of azimuth is $6'\ 18''$, to bring it into the plane of the meridian

After the instrument has been completely adjusted to the plane of the meridian, it

Digitized by Google

is usual to fix a meridian mark on some distant object to the north, and another to the south; and, by mean of these marks, the observer can ascertain, with much certainty, whether the instrument has been altered in its adjustments, from any accidental cause, since the last time it was used. Sometimes, with an additional glass to correspond to the distance of the mark, and a scale of seconds of azimuth made near the meridian mark, we may correct the instrument for a few seconds' motion in azimuth, when correcting the adjustment in the manner we have just been speaking of. We may here remark, that the instrument ought to be fixed on some very stable support (as, for example, a stone block, imbedded in the ground five or six feet), and in as retired a situation as possible, to avoid the tremulous action from the motion of carriages, &c. It will also be extremely convenient, as well as conducive to accuracy, to have the instrument covered by a low building, with slits in the roof on the north and south, fixed with movable shutters, so that the particular part of the northern or southern sky, where the observed star is situated, may be visible, while the rest is covered over to prevent the entrance of too much stray light to the eye, when observing in the twilight, or in the day-time. As a greater security from the interference of this kind of light, the observer may place a thick cloth over his head, with a part of it very near the eye end of the telescope, which will serve very well to protect the eye from any other light except that which passes through the telescope.

Second Method. This method of adjusting the instrument to the plane of the meridian, is by means of two well-known circumpolar stars, of nearly the same declination, and differing nearly twelve hours in right ascension, by observing the one above, and the other below the pole. Then it is evident that any deviation in the instrument from the meridian, will produce contrary effects upon the observed times of transit, exactly as in the upper and lower transits of the same star. Here the time which elapses between the two observations, will differ from the time which would elapse according to the catalogue, by the sum of the effects of the deviation upon the two stars. We have given, in Table C, at the end of this article, the corrections in the times of the upper and lower transits of stars, for various declinations, and in different latitudes, supposing the instrument to be 16′ 40″, or 1000″, in azimuth from the plane of the meridian. Thus, if, in the latitude of 40°, we make an observation of the upper transit of a star whose polar distance is 25°, and, at about the same time, the lower transit of another star whose polar distance is 30°, we shall find from the table that the correction of the upper transit is 66ˢ, and of the lower 131ˢ, for 1000″ of azimuth. If the deviation of the instrument were to the east of the meridian, by the quantity 1000″, the upper transit would be observed too early by 66ˢ, and the lower too late by 131ˢ; consequently, the difference between the observed transits, and the times of passing the meridian given by the tables, would be $66^s + 131^s = 197^s$. Suppose, now, by actual observation it was found that this difference, instead of being 197ˢ, was only 50ˢ; we should obtain the corresponding correction of azimuth by saying, As 197ˢ is to 50ˢ, so is 1000″ to 254″; and, to correct this error, we must move the azimuth screw *a* so as to give the instrument an increase of 254″ north-westerly azimuth. In like manner we find the corrections of the times of the transit, by saying, As 197ˢ is to 50ˢ, so is 66ˢ to 17ˢ, the correction of the upper transit; or, As 197ˢ is to 50ˢ, so is 131ˢ to 33ˢ, the correction of the lower transit; and we must use these numbers for correcting the position of the instrument, in the same manner as we have before directed. Thus, in the above example, the star which was observed approaching towards the meridian, at the upper transit, was 17ˢ from the meridian in time; therefore, at the next upper transit of the same star, we must observe it passes the middle wire of the telescope, and then, by means of the azimuth screw *a*, keep the star constantly bisected by the wire during 17 seconds of time, and then, if the observation has been accurately made, the instrument will be in the plane of the meridian.

In determining the direction of the deviation, it must be recollected, that when the deviation is to the east, the star above the pole passes too early, and that below the pole too late; therefore, if the upper star precedes, the interval by observation will exceed the true interval, between the passages of the two stars; but if the lower star precedes, the interval by observation will be less than the true interval. The contrary takes place when the deviation is to the west of the meridian. This method may be used advantageously with δ Ursæ Minoris, and Cephei 51 Hev., which are given in the Nautical Almanac. In like manner, the pole-star may be combined with the stars of the Great Bear.

Third Method. This method consists in observing the transits of any two stars, differing from each other considerably in declination, and but little in right ascension. The nearer the observations of the stars are to each other, the better, as this prevents

Digitized by Google

the possibility of any error arising from a change in the rate of the time-keeper And, as the apparent places of one hundred principal stars are now given in the Nautical Almanac, for every tenth day, it will be better to select two stars from that work. The principle upon which this third method is grounded, is, that a high star is less affected by a deviation of the instrument from the plane of the meridian, than a low star; hence it is evident that if the observed differences of the transits, reduced to sideral time, be exactly equal to the difference of the computed right ascensions, the instrument will be correctly placed in the plane of the meridian; if not, by repeated operations, by methods similar to those before explained, the adjustments must be completed. The restricted limits of this article do not allow us to go into many minute details which are used in large observatories. What we have here given will be sufficient for all the purposes to which a portable transit instrument is usually applied.

To observe the transit of any heavenly body over the meridian.

Having, by means of the previous adjustments, made the line of collimation describe a great circle, passing through the zenith of the place, and the north and south points of the horizon, the instrument will be in a fit state for making the observations. We have said that the telescope contains five vertical and two horizontal wires, placed a short distance from each other. These last are intended to guide the observer in bringing the object to pass across the middle wire of the field, by moving the telescope till it appear between them. The central vertical wire is in the meridian, and the instant of passing this wire will be the time of the passage on the meridian by that star: but as, in noting the time, it will not often happen that an exact second will be shown by the clock, when the star is bisected by the wire, but it will pass the wire in the interval between two successive seconds; the observer must, therefore, whilst watching the star, listen to the beats of his clock, and count the seconds as they elapse: he will then be able to notice the space passed over by the star in every second, and, consequently, its distance from the wire at the second before it arrives at, and the next second after it has passed, the wire; and, with a little practice, he will be able to estimate the fraction of a second at which the star was on the wire, to be added to the previous second. Thus, if the observation of passing the wire was midway between the 7th and 8th seconds, the time of the transit would be $7^s.5$; but if it appeared more distant on the one side than on the other, it would be $7^s.3$, or $7^s.7$, &c., according to its apparent relative distance from the wire.

This kind of observation must be taken at each of the five wires, and a mean of the whole taken, which will represent the time of the star's passage over the mean or meridional wire. The utility of having five wires, instead of the central one only, will be readily understood from the consideration that a mean result of several observations is deserving of more confidence than a single one.

In observing the sun, the times of passing of both the first and second limbs over the wires, are to be observed and set down as distinct observations; the mean of both observations gives the time of the passing. of the centre across the meridian. The wires of the instrument are generally placed, by the maker, at such a distance from each other, that the first limb of the sun passes all of them before the second limb arrives at the first wire, and the observer can thus take the observations without hurry or confusion.

The round limb only of the moon can be observed, except within an hour or two of the full moon. In observing the larger planets, the first and second limb may be observed alternately over the five wires; that is, the first limb must be observed at the 1st, 3d, and 5th wires, and the second limb at the 2d and 4th wires; and, by reducing these observations in the same manner as those of the sun, we obtain the meridional passage of the centre. When an observation at one or more of the wires has been lost, it is impossible to take the mean in the same way as in a perfect observation. If the centre wire is the one that is deficient, the mean of the other four may be taken as the time of the meridional passage; or the mean of any two, equally distant on each side of the centre, supposing the intervals of the wires to be equal. But when any of the side wires are lost, and, indeed, under any circumstances of deficiency in the observation, the most correct method of proceeding is as follows:—Find, by a considerable number of careful observations, over all the wires, the equatorial interval between each side wire, and the central one. These intervals are to be set down for future use. Then, when part of the wires only are observed, each wire is to be reduced to the mean, by adding to, or subtracting from, the time of observation, as the case may be, the equatorial interval between that wire and the centre wire, multiplied by the secant of the declination of the star

Digitized by Google

We shall hereafter show the use of the transit instrument in regulating a chronometer; and for determining the longitude, by means of the observations of the transits of the moon and moon-culminating stars.

TABLE A.

Correction, in seconds of time, to be applied to one fourth part of the difference of the two intervals, supposing the whole difference to be 1000ˢ of time.

This correction is *subtractive* from the quarter interval, at the *upper* transit; *additive* to the quarter interval at the *lower* transit.

Lat.	*Pole Star.*	*Polar Distance of the Star.* 0°	5°	10°	15°	20°	25°	30°	35°	40°
°	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
0	0	0	0	0	0	0	0	0	0	0
10	1	0	4	8	12	16	21	25	31	37
20	2	0	8	16	24	33	42	53	64	76
30	4	0	13	25	34	53	67	83	101	121
35	5	0	15	31	47	64	82	101	123	147
40	6	0	18	37	56	76	98	121	147	176
42	6	0	20	40	60	82	105	130	158	189
44	7	0	21	43	65	88	113	139	169	
46	7	0	23	46	69	94	121	149	181	
48	8	0	24	49	74	101	130	160	194	
50	8	0	26	52	80	108	139	172		
52	9	0	28	56	86	116	149	185		
54	9	0	30	60	92	125	160	199		
56	10	0	33	65	99	135	173			
58	11	0	35	70	107	146	187			
60	12	0	38	76	116	158				

The difference of the two intervals actually observed, is to be multiplied by the number given by this table, and the product divided by 1000 (which is the same as to cross off the three right-hand figures); the quotient is the correction to be applied to one fourth part of the difference of the intervals.

TABLE B.

Correction of the azimuth, in minutes and tenths of a minute of space, corresponding to a difference in the two intervals of 1000 seconds in time.

Lat.	*Pole Star.*	*Polar Distance of the Star.* 0°	5°	10°	15°	20°	25°	30°	35°	40°
°	′ ″		′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
0	1.00	0	5.29	11.02	16.47	22.47	29.13	36.11	43.53	52.35
10	1.43	0	5.34	11.13	17.03	23.10	29.40	36.44	44.33	53.23
20	1.48	0	5.50	11.46	17.52	24.16	31.06	38.30	46.42	57.16
30	1.57	0	6.20	12.46	19.23	26.20	33.45	41.47	50.40	60.43
35	2.04	0	6.42	13.29	20.30	27.51	35.40	44.10	53.34	64.11
40	2.12	0	7.09	14.25	21.55	29.46	38.09	47.14	57.17	68.38
42	2.16	0	7.23	14.52	22.36	30.42	39.19	48.41	59.03	70.45
44	2.21	0	7.37	15.22	23.21	31.42	40.37	50.18	61.00	
46	2.26	0	7.54	15.54	24.10	32.50	42.04	52.05	63.10	
48	2.31	0	8.12	16.31	25.06	34.05	43.40	54.04	65.35	
50	2.38	0	8.32	17.11	26.07	35.29	45.28	56.17		
52	2.45	0	8.54	17.57	27.16	37.03	47.28	58.46		
54	2.52	0	9.20	18.48	28.34	38.48	49.43	61.33		
56	3.01	0	9.48	19.46	30.02	40.47	52.16			
58	3.11	0	10.21	20.51	31.04	43.03	55.09			
60	3.23	0	10.58	22.06	33.35	45.37	58.27			

Digitized by Google

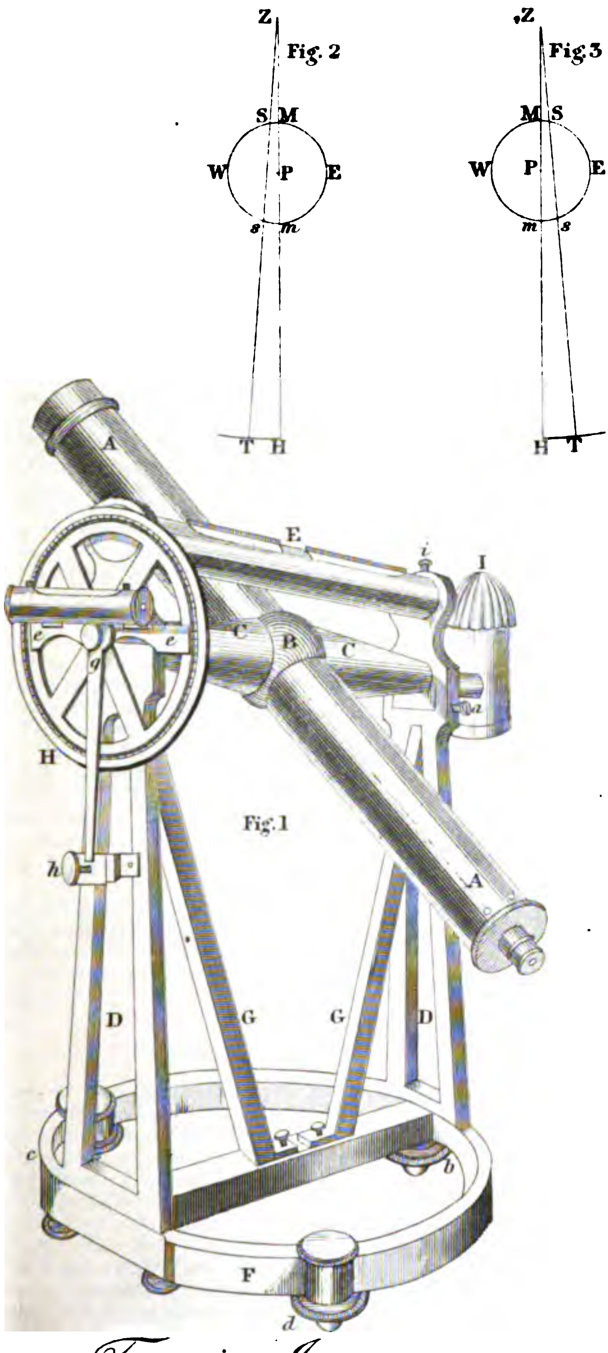
TABLE C.

Correction, in seconds of time, for 1000 seconds of space of deviation in azimuth from the plane of the meridian, to be applied to the time of the transit of the star observed by the transit instrument.

Upper Transit.										Lower Transit.									
Lat.	Pole Star.	Polar Distance. 5°	10°	15°	20°	25°	30°	35°	40°	Pole Star.	Polar Distance. 5°	10°	15°	20°	25°	30°	35°	40°	Lat.
°	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	°
0	2467	763	383	257	194	157	133	116	103										0
5	2451	751	370	241	176	136	109	89	73	2463	764								5
10	2418	737	360	233	168	129	102	82	66	2441	760	383							10
15	2365	717	347	222	159	121	94	75	59	2400	751	381	257						15
20	2295	691	332	210	149	111	85	66	52	2341	737	377	256	194					20
25	2208	661	314	197	37	101	76	58	44	2264	717	370	253	194	157				25
30	2103	625	293	182	125	90	66	49	35	2170	691	360	248	191	157	133			30
35	1982	584	271	165	111	79	56	40	27	2059	661	347	241	188	155	132	116		35
40	1847	539	246	147	97	66	45	30	18	1932	625	332	233	183	152	131	115	103	40
45	1697	490	220	128	82	54	34	20	9	1791	584	314	222	176	148	128	114	103	45
50	1535	438	191	109	66	41	23	10		1637	539	293	210	168	143	125	112	102	50
55	1360	381	162	88	50	27	12			1469	490	271	197	159	136	121	109	100	55
60	1176	322	131	66	34	14				1291	438	246	182	149	129	115	105	97	60

Digitized by Google

Plate XII



Transit Instrument

Digitized by Google

Digitized by Google

ON PARALLAX, REFRACTION, AND DIP OF THE HORIZON.

PARALLAX (or diurnal parallax) is *the difference between the true altitude of the sun, moon, or star, if it were observed at the centre of the earth, and the apparent altitude observed, at the same instant, by a spectator, at any point on the surface of the earth.*

Thus, in Plate XII., figure 3, let ABC be the earth, C its centre, A the place of a spectator, ZAK a vertical plane, passing through the place D of the moon, or the place d of a planet; EDF, edG, circular arcs drawn about C as a centre, and KZ part of the starry heavens. Then, if at any time the moon be at D, she will be referred to the point H, by a spectator supposed to be placed at the centre of the earth, and this is called the *true place* of the moon; but the spectator at A will refer the moon to the point b, and this is called the *apparent place* of the moon; the difference Hb (or the angle HDb = ADC) is called the moon's *parallax in altitude*, which is evidently greatest when the moon is in the horizon at E, being then equal to the arc KI, and it decreases from the horizon to the zenith, and is there nothing. The parallax is less as the objects are farther from the earth: thus the parallax of a planet at d is represented by ab, being less than that of the moon at D; and the horizontal parallax Kf of the planet is less than the horizontal parallax KI of the moon. As the parallax makes the objects appear lower than they really are, it is evident that the parallax must be added to the apparent altitude to obtain the true altitude. Having the horizontal parallax, the parallax in altitude is easily found by the following rule:—*As radius is to the cosine of the apparent altitude, so is the horizontal parallax to the parallax in altitude.* This rule may be easily proved; for in the triangle CAE we have CE : CA :: radius : sine CEA; and in the triangle CDA we have CD (or CE) : CA :: sine CAD : sine CDA; hence we have radius : sine CEA :: sine CAD : sine CDA; but CEA = horizontal parallax, CDA = parallax in altitude, and sine CAD = cosine app. alt. Hence we have radius : cosine app. alt. :: sine hor. par. : sine par. in alt.; but the parallaxes of the heavenly bodies being very small, the sines are nearly proportional to the parallaxes; hence we may say, As radius : cosine app. alt. :: hor. par. : par. in alt.

The sun's mean parallax in altitude is given in Table XIV., for each 5° or 10° of altitude. The moon's horizontal parallax is given in the Nautical Almanac, for every noon and midnight at the meridian of Greenwich; also that of the sun for every ten days, and the parallaxes of Venus, Mars, Jupiter, and Saturn, for every five days, throughout the year.

Refraction of the heavenly bodies.

It is known, by various experiments, that the rays of light deviate from their rectilinear course, in passing obliquely out of one medium into another of a different density; and if the density of the latter medium continually increase, the rays of light, in passing through it, will deviate more and more from the right lines in which they were projected towards the perpendicular to the surface of the medium. This may be illustrated by the following experiment:—Make a mark at the bottom of any basin, or other vessel, and place yourself in such a situation that the hither edge of the basin may just hide the mark from your sight; then keep your eye steady, and let another person fill the basin gently with water; as the basin is filled, you will perceive the mark come into view, and appear to be elevated above its former situation. In a similar manner, the light, in passing from the heavenly bodies through the atmosphere of the earth, deviates from its rectilinear course. By this means the objects appear higher than they really are, except when in the zenith. This apparent elevation of the heavenly bodies above their true places, is called the refraction of those bodies. To illustrate this, let ABC (Plate XII., fig. 2) represent the atmosphere surrounding

Digitized by Google

the earth DEF, and let an observer be at D, and a star at a; then, if there were no refraction, the observer would see the star according to the direction of the right line D a; but as the light is refracted, it will, when entering the atmosphere near A, be bent from its rectilinear course, and will describe a curve line from A to D, and, at entering the eye of the observer at D, will appear in the line D b, which is a tangent to the curve at the point D, and the arc ab will be the refraction in altitude, or, simply, the refraction, which must be subtracted from the observed altitude to obtain the true.

At the zenith, the refraction is nothing; and the less the altitude, the more obliquely the rays will enter the atmosphere, and the greater will be the refraction: at the horizon, the refraction is greatest. In consequence of the refraction, any heavenly body may be actually below the horizon when appearing above it. Thus, when the sun is at T below the horizon, a ray of light TI, proceeding from T, comes in a right line to I, and is there, on entering the atmosphere, turned out of its rectilinear course, and is so bent down towards the eye of the observer at D, that the sun appears in the direction of the refracted ray above the horizon at S.

The mean quantity of the refraction of the heavenly bodies is given in Table XII All observed altitudes of the sun, moon, planets, or other heavenly bodies, must be decreased by the numbers taken from that table corresponding to the observed altitude of the object. The refraction varies with the temperature and density of the air, increasing by cold or greater density, and decreasing by heat and rarity of the atmosphere. The corrections to be applied to the numbers taken from Table XII, for the different heights of Fahrenheit's Thermometer and the Barometer, are given in Table XXXVI.* Thus, if the refraction be required for the apparent altitude 5°, when the thermometer is at 20°, and the barometer at 30.67 inches, we shall have the mean refraction by Table XII. equal to 9′ 53″, and by Table XXXVI. the correction corresponding to the height of the thermometer 20° equal to + 48″, and for the barometer 30.67 equal to + 22″; hence the true refraction will be $9' 53'' + 48'' + 22'' = 11' 3''$.

There is sometimes an irregular refraction near the horizon, caused by the vapors near the surface of the earth; the only method of avoiding the error arising from this source, which is sometimes very great, is to take the observations at a time when the object which is observed is more than 10° above the horizon.

The refraction makes any terrestrial object appear more elevated than it really is. The quantity of this elevation varies, at different times, from $\frac{1}{7}$ to $\frac{1}{34}$ of the angle formed, at the centre of the earth, between the object and the observer; but, in general, this refraction is about $\frac{1}{14}$ of that angle.

Dip of the horizon.

Dip of the horizon is the angle of depression of the visible horizon below the true or sensible horizon (touching the earth at the observer), arising from the elevation of the eye of the observer above the level of the sea. Thus, in Plate XII., figure 1, let ABC represent a vertical section of the earth, whose plane, being produced, passes through the observer and the object, and let AE be the height of the eye of the observer above the surface of the earth; then FEG, drawn parallel to the tangent to the surface at A, will represent the true horizon, and EIH, touching the earth at I, will represent the apparent horizon; therefore the angle FEH will be the dip of the horizon. Let M be an object whose altitude is to be observed by a fore observation by bringing the image in contact with the apparent horizon at H; then will the angle MEH be the observed altitude, which is greater than the angle MEF (the altitude independent of the dip) by the quantity of the angle FEH; so that, in taking a fore observation, the dip must be subtracted from the observed altitude to obtain the altitude corrected for the dip. In a back observation, the apparent horizon is in the direction EK; and, by continuing this line in the direction EL, we shall have the observed altitude MEL; and it is evident that to this the dip LEF (= KEG) must be added to obtain the altitude corrected for the dip.

In Table XIII. is given the dip, for every probable height of the observer, expressed in feet. In calculating this table, attention is paid to the terrestrial refraction, which decreases the dip a little, because IE becomes a curve line instead of a straight one, and EH is a tangent to that curve in the point E.

* This table is to be entered with the height of the thermometer or barometer at the top, and the apparent altitude at the side; under the former, and opposite the latter, will be the correction corresponding to the thermometer or barometer, which is to be applied to the mean refraction, by addition or subtraction, according to the signs at the top of the columns respectively.

Digitized by Google

What has been said concerning the dip of the horizon, supposes it free from all encumbrances of land or other objects; but, as it often happens, when ships are sailing along shore, or at anchor in a harbor, that an observation is wanted when the sun is over the land, and the shore nearer the ship than the visible horizon would be if it were unconfined, in this case, the dip of the horizon will be different from what it otherwise would have been, and greater the nearer the ship is to that part of the shore to which the sun is brought down. For this reason Table XVI. has been inserted, which contains the dip of the sea at different heights of the eye, and at different distances of the ship from the land. This table is to be entered at the top with the height of the eye of the observer above the level of the sea in feet; and in the left-hand side column, with the distance of the ship from the land in sea miles and parts. Under the former, and opposite the latter, stands the dip of the horizon, which is to be subtracted from the altitude observed by a fore observation, instead of the numbers in Table XIII.

The distance of the land requisite in finding the dip from Table XVI., may be found nearly in the following manner:—Let two observers, one placed as high on the main-mast as he can conveniently be, and the other on the deck immediately beneath him, observe, at the same instant, the altitude of the sun or other object that may be wanted, and let the height of the eye of the upper observer above that of the lower be measured in feet, and multiplied by 0.56; then the product, being divided by the difference of the observed altitudes of the sun in minutes, will be the distance in sea miles, nearly.

Thus, if the eye of the upper observer was 68 feet higher than that of the lower, and the two observed altitudes of the sun 20° 0′ and 20° 12′, the distance of the land, in sea miles, would be 3.2. For $68 \times 0.56 = 38.08$, and this, being divided by the difference of the two observed altitudes of the sun 12′, gives 3.2, nearly. Now, if the lower observer be 25 feet above the level of the sea, the dip corresponding to this height and the distance 3.2 miles will be 6′, which, being subtracted from 20° 0′, leaves 19° 54′, the altitude corrected for the dip.

The dip may be calculated, in this kind of observations, to a sufficient degree of accuracy, without using Table XVI., in the following manner:—Divide the difference of the heights of the two observers in feet, by the difference of the observed altitude in minutes, and reserve the quotient. Divide the height of the lower observer in feet by this reserved number, and to the quotient add one quarter of the reserved number and the sum will be the dip in minutes corresponding to the lower observer. Thus, in the above example, $\frac{68}{12} = 5'.6$ is the reserved number, and $\frac{25}{5.6} = 4.4$; to this add one fourth of 5′.6 or 1′.4, and the sum will be the dip 5′.8, or nearly 6′, corresponding to the lower observer, being the same as was found by the table.

Digitized by Google

TO FIND THE SUN'S DECLINATION.

THE declination of the sun is given, to the nearest minute, in Table IV., for every noon, at Greenwich, from the year 1833 to 1848; and this table will answer for some years beyond that period, without any material error. If great accuracy is required, the declination may be taken from the Nautical Almanac.* This declination may be reduced to any other meridian, by means of Table V., in the following manner:—

To find the sun's declination, at noon, at any place.

RULE.

Take out the declination at noon, at Greenwich, from Table IV., or from the Nautical Almanac; then find the longitude from Greenwich in the top column of Table V., and the day of the month in the side column; under the former, and opposite to the latter, is a correction, in minutes and seconds, to be applied to the declination taken from Table IV.; to know whether this correction be additive or subtractive, you must look at the top of the column where you found the day of the month, and you will see it noted whether to add or subtract, according as the longitude is east or west. This correction being applied, you will have the declination at noon at the given place.

EXAMPLE I.

Required the declination of the sun, at the end of the sea day, October 10, 1864, in the longitude of 130° E. from Greenwich.

Sun's declination, October 10, at Greenwich, at the end of the sea day, or beginning of the day in the N. A., by Table IV.	6° 51′ S.
Variation of dec., Table V., October 10, in 130° E. long. .... sub.	0 8
True dec. noon, October 10, in long. 130° E.	6 43 S.

EXAMPLE II.

Required the sun's declination at noon ending the sea day of March 12, 1864, in the longitude of 65° W. from Greenwich.

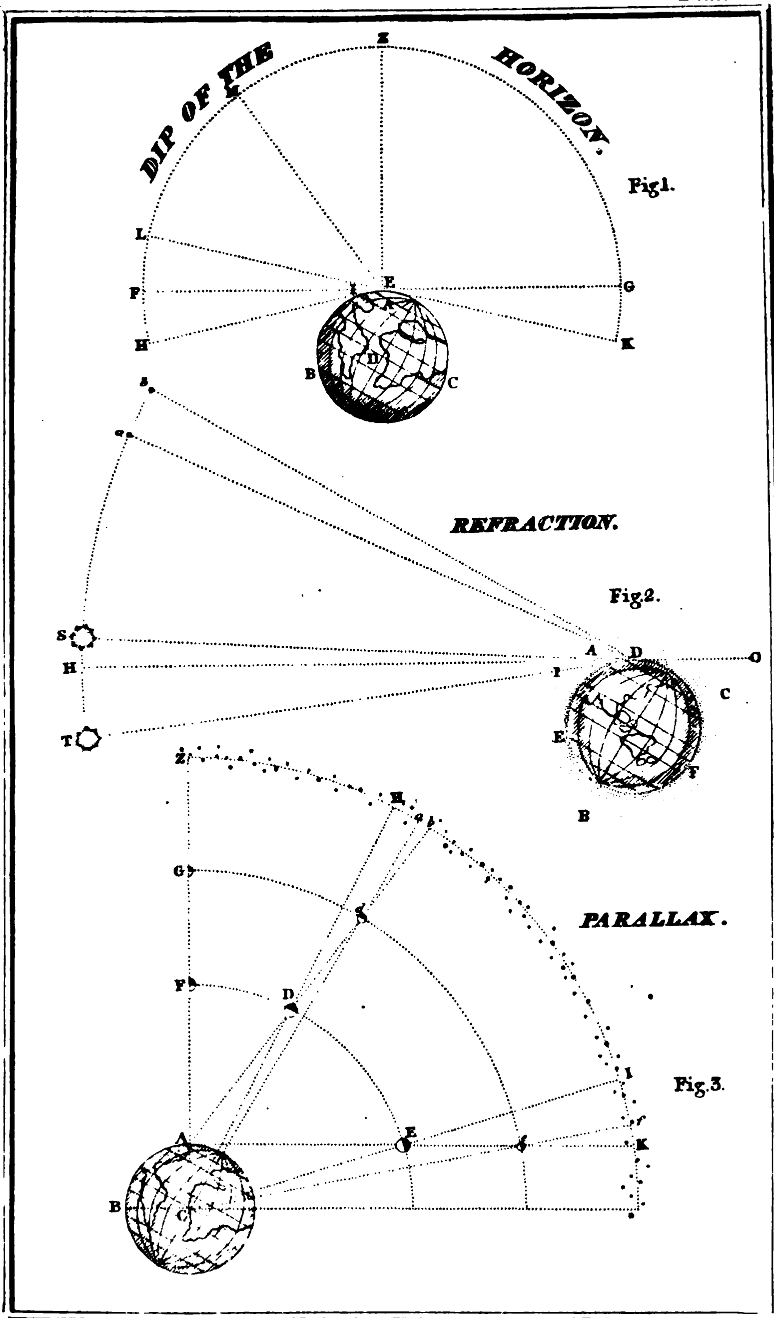
Sun's declination, March 12, by Table IV.	3° 6′ S
Var. Table V., March 12, long. 65° W. .... sub.	4
True declination, noon, March 12, long. 65° W.	3 2 S

The preceding correction ought always to be applied to the declination used in working a meridian observation to determine the latitude, though many mariners are in the habit of neglecting it.

* In finding the declination, or any other quantity, in the Nautical Almanac, you must be careful to note the difference between the civil, nautical, and astronomical account of time. The civil day begins at midnight, and ends the following midnight, the interval being divided into 24 hours, and is reckoned in numeral succession from 1 to 12, then beginning again at 1 and ending at 12. The nautical or sea day begins at noon, 12 hours before the civil day, and ends the following noon; the first 12 hours are marked P. M., the latter A. M. The astronomical day begins at noon, 12 hours after the civil day, and 24 hours after the sea day, and is divided into 24 hours, numbered in numeral succession from 1 to 24, beginning at noon, and ending the following noon. All the calculations of the Nautical Almanac are adapted to astronomical time; the declination marked in the Nautical Almanac, or in Table IV., is ~~adapted to the beginning of the astronomical day~~, or to the end of the sea ~~day, it being at~~ the end of the sea day when mariners want the declination to determine their latitude. It would be much better if seamen would adopt the astronomical day, and wholly neglect the old method of counting by the sea day

Digitized by Google

Plate XIII.



Digitized by Google

To find the sun's declination, at any time, under any meridian.

RULE.

Reduce the sun's declination at noon at Greenwich, to noon under the given meridian, by the preceding rule; then enter Table V. with the time from noon at the top, and the day of the month in the side column; under the former, and opposite the latter, will be the correction to be applied to that reduced declination. To know whether this correction be additive or subtractive, you must look at the top of the column where you found the day of the month, and you will find it noted whether to add or subtract, according as the time is before or after noon.

EXAMPLE III.

Required the sun's declination October 10, 1864, sea account, at 8^h 21^m in the forenoon, in the longitude of 130° E. from Greenwich.

Sun's declination Oct. 10, at Greenwich, at noon, by Table IV.	6° 51	S
Variation for 130° E. long. ..subtract	8	
Declination at noon, October 10, in long. 130° E.	6 43	S.
Variation of dec. for 3^h 39^m from noon,* Oct. 10, ...subtract	3	
True dec. Oct. 10, sea acc. in long. 130° E. at 8^h 21^m, A. M.	6 40	S.

EXAMPLE IV.

Required the sun's declination May 10, 1836, sea account, at 5^h 30^m, P. M., in the longitude of 35° 45′ E. from Greenwich.

Variation of declination, May 10, in long. 35° 45′ E. ...subtract	1′ 38″	
Variation of declination for 5^h 30^m, P. M. ...add	3 44	
Diff. is additive, because the greatest number is so.	2 06	
May 10, sea account, is May 9, by N. A., at which time the sun's declination	17° 26 27	
True dec. May 10, 5^h 30^m, P. M., sea account, in long. 35° 45′ E.	17 28 33	N

EXAMPLE V.

Required the sun's declination March 26, 1836, sea account, at 3^h, P. M., in the longitude of 140° W. from Greenwich.

Variation of declination, March 26, in long. 140° W. ...add	9′ 08″	
Variation for 3^h, P. M. ...add	2 56	
Sum	12 04	
March 26, sea account, is March 25, by N. A., at which time the sun's declination	1° 56 41	N
True dec. March 26, 3^h, P. M., sea account,	2 08 45	N

* In the present example, the time is Oct. 10, 8^h 21^m, A. M., which evidently wants 3^h 39^m of the end of the sea day, Oct. 10, for which time the declination is marked in Table IV.

Digitized by Google

VARIATION OF THE COMPASS.

It was many years after the discovery of the compass, before it was suspected that the magnetic needle did not point accurately to the north pole of the world; but, about the middle of the sixteenth century, observations were made in England and France, which fully proved that the needle pointed to the eastward of the true north. This difference is called the *variation of the compass*, and is named *east* when the north point of the compass (or magnetic north) is to the eastward of the true north, but *west* when the north point of the compass is to the westward of the true north. The quantity of the variation may be found by observing, with a compass, the bearing of any celestial object when in the horizon, (or, as it is called, the *magnetic amplitude*;) the difference between this and the true amplitude, found by calculation, will be the variation. The same may be obtained by observing the *magnetic azimuth* of any celestial object, (that is, its bearing by a compass when elevated above the horizon;) the difference between this and the true azimuth, found by calculation, will be the variation.

Some years after the discovery of the variation, it was found that it did not remain constant; for the easterly variation, observed in England, gradually decreased till the needle pointed to the true north, and then increased to the westward, and is now above two points.

As all the courses steered by a compass must be corrected for the variation, to obtain the true courses, it is of great importance to the navigator to know how to find the variation at any time. To do this, it is necessary to find the magnetic amplitude or azimuth of a celestial object, which may be done as follows:—

*To observe an amplitude by an azimuth compass.**

When the centre of the sun is about one of his diameters † above the horizon, turn the compass round in the box, until the centre of the sun is seen through the narrow slit which is in one of the sight-vanes, exactly on the thread which bisects the slit in the other: ‡ at that instant push the stop, which is in the side of the box, against the edge of the card, and the degree and parts of a degree which stand against the middle line on the top, will be the magnetic amplitude of the sun at that time, which is generally reckoned from the east or west point of the compass.

To observe an azimuth by an azimuth compass.

Turn the compass round in the box until the centre of the sun is seen through the narrow slit which is in one of the sight vanes, exactly on the thread which bisects the slit on the other, or until the shadow of the thread falls directly along the line of the horizontal bar; ‡ the card is then to be stopped, and the degree and parts of a degree which stand against the middle line of the stop, will be the magnetic azimuth of the sun at that time, which is generally reckoned from the north in north latitude, and from the south in south latitude. § At the time of making this observation, you must also observe the altitude of the sun, in order to obtain the true azimuth.

What is here said of the sun, is alike applicable to the moon, planets, and stars.

---

* The figure of an azimuth compass, furnished with sight-vanes, is given in Plate VI., figure 5. The card of this compass is similar to that of a common compass.

† The observation is to be taken at that altitude on account of the dip, refraction, and parallax, the correction of altitude depending on these causes being, in general, nearly equal to the sun's diameter.

‡ If the instrument is furnished with a magnifying glass fixed to one of the vanes, you may (instead of proceeding as above) turn the compass box until the vane is directed towards the sun, and when the bright speck (or rays of the sun collected by the magnifying glass) falls upon the slit of the other vane, or upon the line in the horizontal bar, the card is to be stopped, and the divisions read off as above.

§ If the compass vibrate considerably at the time of making the observations, it would be conducive

Digitized by Google

To find the true amplitude.

RULE.

BY LOGARITHMS.—*To the log. secant of the latitude (rejecting 10 in the index) add the log. sine of the sun's declination;* * *the sum will be the log. sine of the true amplitude, or distance of the sun from the east or west point, towards the north in north declination, but towards the south in south declination.*

BY INSPECTION.—*Find the declination at the top of Table VII., and the latitude in the side column; under the former, and opposite the latter, will be the true amplitude.* When great accuracy is required, you may proportion for the minutes of latitude and declination.

EXAMPLE I.

Required the sun's true amplitude, at rising, in the latitude of 39° 0′ N., on the 22d of December, 1848 when his declination was 23° 28′.

BY LOGARITHMS.

Latitude	39°	0′	Log. Sec.	0.10950
Sun's declin.	23	28	Log. Sine,	9.60012
True ampli.	30	49	Log. Sine,	9.70962

BY INSPECTION.

Under the declination 23° 28′, and opposite the latitude 39°, stands the true amplitude 30° 49′.

Hence the true bearing or amplitude of the sun at rising is E. 30° 49′ S., and a setting it is W. 30° 49′ S.

EXAMPLE II.

Required the moon's true amplitude at setting, in the latitude of 35° 8′ N., when her declination is 13° N.

BY LOGARITHMS.

Latitude	35°	8′	Log. Sec.	0.08734
Moon's declin.	13	0	Log. Sine,	9.35209
True ampli.	15	58	Log. Sine,	9.43943

BY INSPECTION.

Under the declination 13°, and opposite the latitude 35°, stands 15° 56′, which is nearly the true amplitude; the exact value may be found by finding the amplitude for 36° latitude, and proportioning the difference for the miles in the latitude.

Hence the true amplitude at setting is W. 15° 58′ N., and at rising E. 15° 58′ N.

EXAMPLE III.

Required the sun's true amplitude in the latitude of 42° 30′ N., when his declination was 20° S.

BY LOGARITHMS.

Latitude	42°	30′	Log. Sec.	0.13237
Sun's declin.	20	00	Log. Sine,	9.53405
True ampli.	27	38	Log. Sine,	9.66642

BY INSPECTION.

Under the declination 20°, and opposite the latitudes 42° and 43°, stand 27° 24′ and 27° 53′; the mean of these gives the true amplitude for the latitude of 42° 30 = 27° 38′.

Hence the amplitude at setting is W. 27° 38′ S., and at rising E. 27° 38′ S.

To find the true azimuth at any time.

At the time of observing the magnetic azimuth, you must also observe the altitude of the object; this altitude must be corrected as usual for the dip, parallax, refraction,† &c., in order to obtain the true altitude; you must also find the declination of the

---

to accuracy to take several azimuths and altitudes, and to take the mean of all the azimuths and all the altitudes, and work the observation with the mean azimuth and altitude. The same is to be observed in taking an amplitude.

* The declination of the sun at noon is given in the Nautical Almanac, and in Table IV., and must be corrected for the longitude of the ship and the hour of the day, by means of Table V.

† In observations of the altitude of the sun's lower limb by a fore observation, it is usual to add 12 for the effect of dip, parallax, and semi-diameter. The refraction is to be subtracted from the sum and the remainder will be the true altitude, nearly.

Digitized by Google

object,* and the latitude of the place of observation, and then the true azimuth may be calculated by the following rule:—

RULE.

Add together the polar distance,† the latitude, and the true altitude; take the difference between the half-sum and the polar distance, and note the remainder. Then add together the log. secant of the latitude, the log. secant of the altitude, (rejecting 10 in each index,) the log. cosine of the half-sum, and the log. cosine of the remainder; half the sum of these four logarithms will be the log cosine of half the true azimuth, which, being doubled, will give the true azimuth, reckoned from the north in north latitude, but from the south in south latitude.

EXAMPLE I.

In latitude 51° 32′ N., the sun's true altitude was found to be 39° 28′, his declination being then 16° 38′ N.; required the true azimuth?

Polar distance..........	73° 22′		
Latitude...............	51 32	Secant.................	0.20617
Altitude...............	39 28	Secant.................	0.11239
Sum..................	164 22		
Half-sum..............	82 11	Cosine......... ...	. 9.13355
Polar distance..........	73 22		
Remainder.............	8 49	Cosine......... . .	.. 9.99484
			2)19.44695
Half-sum.....Log. Cosine	58° 4′		9.72347
	2		
True azimuth...........	116 8	from the north.	

The logarithm 9.72347 of this example is also the cosine of 121° 56′, which, being doubled, gives another azimuth 243° 52′, the former being 116° 8′. One of these corresponds to an observation in the forenoon, the other to an afternoon observation.

EXAMPLE II.

In latitude 42° 16′ S., the sun's true altitude was found to be 18° 40′, his declination being then 7° 38′ N.; required the true azimuth.

Polar distance..........	97° 38′		
Latitude...............	42 16	Secant..	0.13076
Altitude...............	18 40	Secant.................	0.02347
Sum..................	158 34		
Half-sum..............	79 17	Cosine...............	9.26940
Polar distance..........	97 38		
Remaindor	18 21	Cosine.....	9.97734
		Sum.....	19.40097
Half-sum...Log. Cosine	59° 53′		9.70048
	2		
True azimuth.........	119 46	from the south.	

QUESTIONS TO EXERCISE THE LEARNER.

Question I. Given the sun's altitude, corrected for dip, refraction, &c., 20° 46′, his declination 17° 10′ S., and the latitude of the place 40° 38′ N.; required the true azimuth.

Answer. 137° 50′ from the north.

* The declination is to be found according to the directions in the note in the last page.

† The polar distance of the sun, moon, or star, is the distance from the elevated pole, and is found by subtracting the declination of the object from 90° when the latitude and declination are of the same name, but by adding the declination to 90° when of different names.

Digitized by Google

Quest. II. What is the sun's azimuth in the latitude of 26° 30′ N. in the forenoon, when his correct central altitude is 24° 28′, and his declination 22° 40′ N.?

Ans. 75° 44′ from the north.

Quest. III. At the island of St. Helena, the sun's true central altitude was found to be 30° 23′ in the forenoon, his declination being then 22° 58′ S.; required the azimuth at that time.

Ans. 72° 21′ from the south.

Quest. IV. What point of the compass did the star Aldebaran bear on, in the latitude of 34° 23′ S., on January 1, 1836, when the correct altitude of that star was 22° 26′?

Ans. 130° 23′ from the south.

Having the true and the magnetic amplitude or azimuth, to find the variation.

Having found the true and magnetic amplitude or azimuth, the variation may be easily deduced therefrom by the following rule, in which the amplitude is reckoned from the east or west point of the horizon, and is called north when to the northward of those points, but south when to the southward. The azimuth is reckoned from the north in north latitudes, but from the south in south latitudes, and is named east when falling on the east side of the meridian, otherwise west. *If the observed and true amplitudes be both north or both south, their difference will be the variation; but if one be north and the other south, their sum will be the variation. If the true and observed azimuths be both east or both west, their difference will be the variation, otherwise their sum; and the variation will be easterly when the point representing the true bearing is to the right hand of the point representing the magnetic bearing, but westerly when to the left hand; the observer being supposed to look directly towards the point representing the magnetic bearing.*

EXAMPLE I.

Suppose the sun's magnetic amplitude at rising is E. 26° 12′ N., and the true amplitude E. 14° 20′ N.; required the variation.

From the greater	E. 26°	12′	N.
Take the less	E. 14	20	N.
Remains variation	11	52	E.

The variation in this example is easterly, because the true amplitude falls to the right of the magnetic.

EXAMPLE II.

The moon's true amplitude at rising was found to be E. 15° 20′ N., and her magnetic amplitude E. 10° 0′ S.; required the variation.

True amplitude	E. 15°	20′	N.
Magnetic amplitude	E. 10	0	S.
Sum is the variation	25	20	W.

EXAMPLE III.

The sun's true azimuth being N. 80° E., and his magnetic azimuth N. 60° E., it is required to find the variation.

True azimuth	N. 80°	E.
Magnetic azimuth	N. 60	E.
Diff. is the variation	20	E.

EXAMPLE IV.

The star Aldebaran was observed at rising to bear by compass E. N. E., when the true amplitude was N. E. by E.; required the variation.

True amp...N. E by E. or	E. 33°	45′	N.
Mag. amp......E. N. E or	E. 22	30	N.
Diff. is the variation... ..	11	15	W

EXAMPLE V.

The true amplitude of the planet Jupiter was E. 10° N. when his magnetic amplitude was E. 20° S.; required the variation

True amplitude	E. 10°	N.
Magnetic amplitude	E. 20	S.
Sum is the variation	30	W

To calculate the variation by observing the sun's azimuth when at equal altitudes in the forenoon and afternoon.

The variation of the compass may also be determined by observing the magnetic azimuths of the sun, in the morning and evening, when at the same altitude, the

Digitized by Google

observer being supposed to be at the same place at both observations; for it is evident that if the declination of the sun do not vary during the time elapsed between the observations, the middle point of the compass between the two bearings will be the bearing of the true north or south point of the horizon, at the place of observation, and the difference between that bearing and the north or south point of the compass will be the variation.

In this kind of observations, it will be convenient always to estimate the magnetic azimuths from the south point of the compass, calling them east or west, as before directed; and this method is supposed to be made use of in the following rule. Then, if one azimuth be east and the other west, half their difference will be the variation, otherwise their half-sum, and the variation will be of the same name as their greater azimuth, excepting, however, where the half-sum is taken and exceeds 90°, in which case its supplement will be the variation, of a different name from the azimuth; the variation being always supposed less than 90°.

If the declination of the sun varies during the elapsed time between the observations (as is generally the case), an allowance may be made for that variation by applying a correction to the afternoon azimuth, calculated by the following rule:—

RULE.

Find, from Table IV., the daily variation of the sun's declination on the day of observation. Then *to the constant logarithm* 9.1249 *add the log. cosine of the latitude of the place, the log. sine corresponding to the elapsed time between the observations found in the column P. M., the Prop. Log. of the daily variation of the sun's declination, and the Prop. Log. of the elapsed time,* estimating hours and minutes as minutes and seconds; the sum, rejecting* 30 *in the index, will be the Prop. Log. of the correction to be applied to the western azimuth, by subtracting when the sun is approaching towards the northern hemisphere, otherwise by adding.*† The azimuth, thus corrected, is to be used in estimating the variation instead of the observed azimuth.

It is not necessary, in this calculation, to find the latitude or declination to any great degree of accuracy, which is the greatest advantage of the method; another of the advantages consists in being able to take a great number of observations, and applying the correction at one operation to the variation deduced from the mean of all the observations, so that, when great accuracy is required (as in taking observations ashore), this method may be used with success; and it is evident that it is alike applicable to the moon or any heavenly body; but the observations must be taken in the same place, as it would increase the calculation considerably to make an allowance for the change of place, as well as for the change of declination; and it would be better, in this case, to calculate each observation separately by the rules before given.

EXAMPLE

Suppose that, on the 10th of April, 1864, in the latitude of 42° 29′ N., longitude 50° W., the sun's morning azimuth is observed to be S. 54° 24′ E., and in the evening, when the sun is at the same altitude, is S. 39° 46′ W., the elapsed time between the observations being 6^h 20^m; required the variation.

Constant logarithm........................			9.1249
Latitude 42° 29′			Cosine 9.8677
Elapsed time 6^h 20^m			Sine 9.8676
Daily variation of declination 22′ P. L.......			.9128
Elapsed time 6^h 20^m, taken as 6′ 20″ P. L....			1.4536
Corr. western azimuth		11′ nearly P. L....	1.2266
Western azimuth	S. 39 46	W.	
Corrected azimuth	S. 39 35	W.	
Morning azimuth	S. 54 24	E.	
Difference........	S. 14 49		

The half of which, 7° 24′, is the variation, which is easterly, because the greater azimuth S. 54° 24′ E. is easterly.

* The elapsed time may be determined by any common watch; but if none be used in the observations, it may be determined as follows:—If one of the observed azimuths be east and the other west, take half their sum, otherwise half their difference, and to the log. sine of this half-sum (or half-difference) add the log. secant of the sun's declination, and the log. cosine of the sun's correct altitude at the time of taking the azimuth; the sum, rejecting 20 in the index, will be the log. sine to be used in the above calculation, and this logarithm will correspond to the elapsed time marked in the column P. M. of Table XXVII.

† In this rule it is supposed that the bearing of the sun by the afternoon observation is to the west-

Digitized by Google

The variation, thus found, is to be allowed on all courses steered by the con pass, to obtain the true courses. To make this allowance, you must look towards the point of the compass the ship is sailing upon, and allow the variation from it *towards the right hand if the variation be east, but to the left hand if the variation be west.* Thus, if a ship steer S. E. with one point westerly variation, the true course will be S. E. by E If the variation be one point easterly, the course will be S. E. by S.

The variation in Cambridge (Mass.), in 1708, was 9° W.; in 1742, 8° W.; in 1782, 6° 46 W.; decreasing about 1¼ minutes per year. At Salem (Mass.), in 1808, it was 5° 20 W.: in London, in 1580, 11° 15′ E.; in 1672, 2° 30′ W.; in 1780, 22° 41′ W.: at Paris, in 1550, 8° E.; in 1660, 0°; in 1769, 20° W. Hence it appears that, at London and Paris, the variation formerly increased 10 or 11 minutes per year; but, by some late observations made in London, it appears to be nearly stationary. Off the Cape of Good Hope, the annual increase is about 7 minutes.

Besides this annual change of the variation, there is also a small *diurnal* change, which, at London, Paris, and Cambridge (Mass.), is from 10′ to 15′ By this quantity the absolute variation, at those places, increases from about 8, A. M., to 2, P. M., when the needle becomes stationary for some time; after that, the variation decreases, and the needle comes back again to its former situation, or nearly so, in the night, or by the next morning.

In addition to the observations contained in the preceding table, it may be observed that the variation, which, at present, is less than ¾ point W. near Cape Cod, decreases in going to the westward along the coast of the United States of America, so that neat Cape Hatteras it is scarcely sensible, and farther to the westward becomes easterly. In the leeward West India Islands it is about ½ point E.; and in the windward islands ¼ point E. Along the northern shore of the Brazils there is a small easterly variation, which decreases in proceeding to the eastward, and becomes westerly near Cape Roque, where it is ¼ point W. In proceeding farther to the southward, along the coast of America, the easterly variation increases so as to be above 2 points E. near Cape Horn, and from thence gradually decreases along the coast of Chili and Peru, so as to be about 1 point E. under the equator near Quito; but in proceeding to the northward towards the N. W. coast of America, the easterly variation increases to more than 2 points.

On the contrary, in proceeding to the eastward of the United States of America, the westerly variation increases, being nearly 1 point W. a little to the eastward of Cape Sable (Nova Scotia), and about 2¼ points W on the E. part of Newfoundland, and at the Western Islands. At the Orkney Islands it is 2½ points westerly, and is nearly the same in the English Channel, and on the coasts of England, Scotland, and Ireland. On the coast of Holland, it is from 1¾ to 2 points W.; in the Cattegat and Sound, about 1½ points W.; in the western part of the Baltic, about 1¼ points; at the entrance of the Gulf of Finland, 1 point W.; in the Bay of Biscay, about 2¼ points W.; near Cape St. Vincents, 2 points W.; in the Mediterranean, from 1 to 1¾ points W.; near Cape Verd (Africa), 1½ points W.; and from thence gradually increases along the western shore of Africa towards the Cape of Good Hope, and is there above 2 points W., and from thence increases towards Cape Lagullas, and a little to the eastward, to 2½ points or 2¾ points W., and then decreases in proceeding along the eastern shore of Africa, and is about ¾ point westerly at the entrance of the Red Sea. In the Arabian Sea, Bay of Bengal, Java Sea, China Sea, and off the coast of Sumatra, it is very small, and on the S. E. part of New Holland is about ¾ point E.

Before the introduction of the method of finding the longitude by lunar observations, and the improvements in the construction of chronometers, and their introduction into common use, it was proposed to find the longitude by means of the observed variation, and charts were constructed for this purpose; but this method is now wholly given up, because there is always a great uncertainty in observations of the variation, since it is not uncommon to find 2 or 3 degrees difference between an azimuth in the morning and evening, when the ship, during that time, has been nearly stationary; the same difference will sometimes be found merely from making the observation when the ship is on a different tack. This is owing to the iron in the ship, which attracts the compass by a force which is generally situated in a point near the centre of the ship. When this point and the compass are in the magnetic

---

ward of the meridian by compass; but if there be a great variation, that bearing might be to the eastward of the meridian by the compass, and, in that case, the correction of the western azimuth must be applied in a contrary manner to the above directions

Digitized by Google

meridian of the compass, the true variation is obtained; but as soon as the position of the ship is changed, so as to bring this point to the eastward or westward of the magnetic meridian passing through the compass, a corresponding change or alteration in the variation to the eastward or westward is immediately perceived. This deviation sometimes amounted to 8° or 9° in the surveys of New Holland. This has since been confirmed by various observations in different places, particularly in the voyages towards the north pole, lately made by order of the English government. The method which was at first used to correct this error, which is sometimes of considerable importance in nautical surveys where great accuracy is required, was to *place the compass always in the same part of the ship*, and to find, by actual observation, the greatest deviation arising from this local attraction, which is when the ship's head is directed east or west. The deviation, when the ship's head is in any other direction, is found by entering Table I. or Table II. in the page corresponding to that direction as a course, and with that greatest error in minutes in the distance column, the corresponding number in the departure column will be the required correction nearly. Thus, if the deviation was 2° 8′ (or 128′) when the ship's head was directed towards the east, the deviation, when in the direction of *one* point from the meridian, (that is, N. by E., N. by W., S. by E., or S. by W.), would be found by entering Table I. in the page for one point, or with the distance 128′, the corresponding departure 25′ would be the correction to be applied on all bearings taken by the compass when in that situation. Mr. Barlow has invented a method of correcting this error, making use of a curious property of the attractive force of iron on the compass, it having been found that this force depends on the *attractive surface*, and not wholly on the quantity of iron; so that a *solid globe* of iron, 30 inches in diameter, would affect the compass exactly in the same manner as a *hollow shell* of the same diameter, made of sheet iron only one tenth of an inch in thickness, though this shell could not contain but *one hundredth part* the quantity of iron which the globe does. Mr. Barlow therefore proposed to have a sheet of iron placed abaft the compass, of such dimensions, and at such a distance, as should be found by experiment to bring the needle back to the magnetic meridian when the ship's head was east or west; then, keeping the iron in that position, it would correct the error of the local attraction of the ship in every direction of the ship's head. This method has been tested by experiment, and found to succeed admirably. It has also been attended with the great advantage of leaving the compass free to act by the natural magnetism of the earth in high latitudes, where the force is much enfeebled by the obliquity of its direction on account of the greatness of the *dip*. In the voyages above named, it was found that the compasses thus furnished traversed freely and accurately, when those of the common form moved very irregularly, and were, in some cases, almost useless.

The Transactions of the Royal Society of London for the year 1833, contain a valuable chart, by P. Barlow, upon which are marked the magnetic lines of equal variations, as they have been observed in late voyages of discovery, surveys, &c. We expect to give, in the collection of tables, a few numerical results from this chart

On the dip of the magnetic needle.

If the needle of a compass be exactly balanced on its point in a horizontal position, and then the magnetic virtue be communicated, the needle will point towards the north, and will also be inclined to the horizon, the north point of the needle tending downwards, and the south point upwards, in northern climates, and the contrary in southern climates. This inclination of the needle to the horizon is called *the dip of the magnetic needle*, which is different in different places, though it has been found to remain nearly the same in the same place, since its discovery in the year 1576, in which year, at London, the dip was 71° 50′; in 1723, it was 74° or 75°; and at present, is about 72½°. Messrs. Humboldt and Biot published a method by which the dip may be calculated for any given place, in north latitudes, to a considerable degree of accuracy. This method is explained in the 22d vol. of Tilloch's Magazine, and is in substance as follows:—

According to their theory, there are *two magnetic poles*, one in the latitude of 79° 1′ N., and in the longitude of 27° 42′ W.* from Greenwich, the other diametrically opposite, in the latitude of 79° 1′ S., and in the longitude of 152° 18′ E. The great

* Capt. Ross, in his voyage to the north, found the northern pole to be in the latitude of 70° 5′ 17 N., and in the longitude of 96° 46′ 45″ W.

Digitized by Google

circle of the earth 90° distant from these poles is called the *magnetic equator*. On the magnetic equator the dip is nothing, and at the poles is 90°; at any other point on the surface of the earth, the dip varies with the distance from the magnetic pole. This distance may be calculated by common spherical trigonometry, or (which is much more simple, and sufficiently accurate for this purpose) by measuring the distance on a terrestrial globe from the magnetic pole to the place for which the dip is to be calculated; then to the log. cotangent of this distance add the constant logarithm 0.30103; the sum will be the log. tangent of the dip. The dip was calculated, on these principles, for twenty-eight places in Europe, Asia, Africa, and America, and in ten places the theory did not differ 1° from actual observations, and in five places did not differ 2°, but at Spitzbergen the difference was between 4° and 5°.

(See page 450.)

Digitized by Google

TO FIND THE LATITUDE BY OBSERVATION.

The latitude of a place, being its distance from the equator, is measured by an arc of the meridian contained between the zenith and the equator; hence, if the distance of any heavenly body from the zenith when on the meridian, and the declination of the object, be given, the latitude may be thence found.

The meridian zenith distance of any object may be found by observing its altitude when on the meridian, or by observing one altitude taken at a given hour from passing the meridian, or by two altitudes taken out of the meridian and the elapsed time between the observations. Each of these methods will be explained by proper examples.

Altitudes of the sun and moon, taken at sea, require four corrections in order to obtain the true altitude of their centres; these are for semidiameter, dip, refraction, and parallax.* When a planet or star is observed, the corrections for dip and refraction only are to be applied, as the semidiameter and parallax of a planet are but a few seconds, and may be neglected in finding the latitude at sea.

In a fore observation with a quadrant, sextant, or circle, the semidiameter is to be added if the lower limb is observed, but subtracted if the upper limb is observed. The dip and refraction are to be subtracted, and the parallax to be added, and the true central altitude will be thus obtained, which, being subtracted from 90°, will give the true zenith distance.

In a back observation with a quadrant, the semidiameter is to be subtracted if the lower limb is observed, but added if the upper limb is observed. The dip and parallax are to be added, and the refraction subtracted, and the central altitude will be obtained, which, being subtracted from 90°, will give the true zenith distance.

In a back observation with a sextant or circle, by measuring the supplement of the altitude, (by bringing the lower limb of the image of the object to touch the back horizon,) the semidiameter and refraction must be added to the true altitude given by the instrument, and the dip and parallax subtracted therefrom, and, by subtracting 90° from the remainder, the true zenith distance will be obtained.

To find the latitude by the meridian altitude of any object.

Having obtained the true meridian zenith distance by either of these methods, you must then find the declination of the object at the time of observation. This may be found for the sun by the Nautical Almanac, or by means of Tables IV. and V., in the manner before explained. The declination of a fixed star may be easily found by inspection in Table VIII., or from the Nautical Almanac. The declination of the moon or a planet may be found, in the Nautical Almanac, in a manner which will be hereafter explained. Having the meridian zenith distance and declination, the latitude is to be found by the following rules.

CASE I.

When the object rises and sets.

RULE.

If the object bear *south* when upon the meridian, call the zenith distance *north*;† but if the bearing be *north*, you must call the zenith distance *south*. Place the zenith

---

* The semidiameter of the sun may be found in the Nautical Almanac, and is nearly 16′. The sun's parallax is found in Table XIV.; the refraction in Table XII.; the dip in Table XIII. The semidiameter and parallax of the moon may be found from the Nautical Almanac, as will be explained hereafter. It may also be observed, that it is usual to add 12′ for the correction for semidiameter, dip, and parallax, in a fore observation of the sun's lower limb, taken upon the deck of a common-sized vessel; and. by subtracting the refraction from the sum, the true altitude will be obtained, nearly; and it ought always to be kept in mind, that the refraction at low altitudes is of too much importance to be neglected.

† In this rule, the sun is supposed to be the fixed point, and the zenith is referred to it. Thus, if the sun bears south from an observer (or from his zenith), the zenith bears north from the sun; and it is this latter bearing which is used in the rule.

Digitized by Google

distance under the declination, and, if they are of the same name, add them together but if they are of different names, take their difference; this sum or difference will be the latitude, which will be of the same name as the greatest number.

CASE II.

When the object does not set, but comes to the meridian above the horizon twice in 24 hours.

Many stars are always above the horizon of certain places of the earth, and, in high latitudes, the sun is sometimes above the horizon for several days, in which case the meridian altitude may be observed twice in 24 hours; that is, once at the greatest height above the pole, and again at the lowest height upon the meridian below the pole. In the former case, the latitude is to be found by the preceding rule, but in the latter by the following:—

RULE.

Add the complement of the declination to the meridian altitude; the sum will be the latitude, of the same name as the declination.

NOTE.—When the sun or star is on the equator, or has no declination, the zenith distance will be equal to the latitude of the place, which will be of the same name as the zenith distance. When the sun or star is in the zenith, the declination will be equal to the latitude, and it will be of the same name as the declination.

To find the latitude by the meridian altitude of the sun or star.

EXAMPLE I.

Suppose that, at the end of the sea day, June 21, 1864, in the longitude of 60° W., the meridian altitude of the sun's lower limb, bearing south, was found by a fore observation to be 40° 6′; required the latitude, supposing the correction of the observed altitude for parallax, dip, and semidiameter, to be twelve miles.

Observed altitude	40°	06′	
Par., dip, and semidiam. ...add		12	
Sum	40	18	
Refraction ...subtract		1	
True altitude	40	17	
Subtract from	90	00	
True zenith distance	49	43	N.
Sun's declination, Table IV.	23	27	N.
Latitude	73	10	N.

EXAMPLE II.

Suppose that, at the end of the sea day, April 14, 1864, in the longitude of 140° E. from Greenwich, the altitude of the sun's lower limb, by a fore observation, was 60° 25′ when on the meridian and bearing south, the correction for dip, semidiameter, and parallax, being twelve miles; required the latitude.

Observed altitude	60°	25′	
Correction ...add		12	
True altitude*	60	37	
Subtract from	90	00	
True zenith distance	29	23	N.
Sun's declination, Table IV. cor. by Table V. for long.	9	27	N.
Latitude	38	50	N.

EXAMPLE III.

Suppose that, at the end of the sea day, May 15, 1864, in the meridian of Greenwich, the meridian altitude of the sun's lower limb, bearing north, was found by a fore observation to be 30° 06′, the correction for parallax, dip, and semidiameter, being twelve miles; required the latitude.

Observed altitude	30°	06′	
Par., dip, and semidiam. ...add		12	
Sum	30	18	
Refraction ...subtract		2	
True altitude	30	16	
Subtract from	90	00	
True zenith distance	59	44	S.
Sun's declination	19	00	N.
Latitude	40	44	S.

EXAMPLE IV.

Suppose that, at the end of the sea day, Nov. 17, 1864, in the longitude of 80° E. from Greenwich, by a fore observation, the meridian altitude of the sun's lower limb was 50° 06′, bearing south, the eye of the observer being seventeen feet above the surface of the sea; required the latitude.

Observed altitude	50°	06′	
Sun's semidiam. ...add		16	
	50	22	
Subtract dip and refraction		5	
True altitude†	50	17	
Subtract from	90	00	
True zenith distance	39	43	N
Sun's dec. cor. by Table V.	19	05	S.
Latitude	20	38	N

* The refraction, being small, is here neglected.
† The parallax, being small, is here neglected, and the sun's semidiameter is supposed to be 16′

Digitized by Google

EXAMPLE V.

By a fore observation, the meridian altitude of the sun's lower limb was found to be 40° 20′, bearing south of the observer, the declination being 9° 56′ N., and the eye twenty-six feet above the horizon;—required the latitude of the place.

Observed altitude...	40° 20′	
Semidiameter ....add	16	
	40 36	
Dip 5′, refraction 1′...subtract	6	
True alt. of the sun's centre *	40 30	
Subtract from...............	90 00	
Zenith distance..............	49 30	N.
Declination..................	9 56	N.
Latitude....................	59 26	N.

EXAMPLE VI.

By a back observation with a quadrant of reflection, the meridian altitude of the sun's lower limb was 25° 12′, when the declination was 21° 14′ S., and the eye of the observer forty feet above the horizon, the sun bearing south; required the latitude of the place of observation.

Observed altitude............	25° 12′	
Semidiameter........subtract	16	
	24 56	
Dip.....................add	06	
	25 02	
Refraction...........subtract	02	
True alt. of the sun's centre *	25 00	
True zenith distance.........	65 00	N.
Declination.................	21 14	S.
Latitude	43 46	N.

EXAMPLE VII.

Suppose that, on January 1, 1830, an observer, seventeen feet above the water, finds by a fore observation that the altitude of Sirius is 53° 33′ when passing the meridian to the southward; required the latitude of the place of observation.

Observed altitude............	53° 33′	
Dip of the horizon....subtract	4	
	53 29	
Refraction...........subtract	01	
	53 28	
True zenith distance.... ..	36 32	N
Sirius declin. Table VIII.†...	16 29	S.
Latitude.......	20 03	N.

EXAMPLE VIII.

Suppose that, on the 13th June, 1864, sea account, an observer, in a high northern latitude, and in the longitude of 65° W. from Greenwich, his eye being twenty feet above the surface of the water, observed by a fore observation the altitude of the sun's lower limb on the meridian below the pole 8° 14′; required the latitude.

The sun being below the pole at 12 hours before the end of the sea day June 13, the correction of declination corresponding in Table V. is — 1′ 46″, and the correction in 65° W. long. is + 0′ 38″; hence both corrections make nearly 1′, to be subtracted from the declination at noon 23° 15′ N., which gives the declination at the time of observation 23° 14′ N., the comp. of which is 66° 46′.

Observed alt. sun's lower limb	8° 14′	
Semidiameter............add	16	
	8 30	
Dip.................subtract	04	
	8 26	
Refraction...........subtract	06	
True alt. of the sun's centre *	8 20	
Complement of declination...	66 46	N.
Latitude.....................	75 06	N.

EXAMPLE IX.

Suppose that, by a back observation with a sextant, the lower limb of the sun's image was brought to the back horizon, and the angle shown by the index was 110° 10′, the sun being then on the meridian and bearing south, the declination being 20° 5′ N., the sun's semidiameter 16′, and the observer 20 feet above the horizon; required the latitude.

Observed angle	110° 10′	
Semidiameter ....add	16	
	110 26	
Dip ....sub.	4	
	110 22	
Subtract	90 00	
Zenith distance ‡...........	20 22	N
Declination	20 05	N
Latitude....................	40 27	N

* The parallax, being small, is here neglected, and the sun's semidiameter is supposed to be 16′.
† The declinations of these bright stars are given for every 10 days in the Nautical Almanac. When great accuracy is required, these declinations should be used instead of the numbers in Table VIII.
‡ The refraction and parallax, being only a few seconds, are neglected.

Digitized by Google

EXAMPLE X.

Suppose that, on January 10, 1830, an observer, eighteen feet above the water, finds the altitude of the north star, when on the meridian below the pole, to be 36° 23′ by a fore observation; required the latitude of the place of observation.

Observed altitude............	36°	23′	
Subtract dip 4′, ref. 1′........		5	
True altitude...............	36	18	
Comp. declin. Table VIII.*...	1	36	N.
Latitude....................	37	54	N.

EXAMPLE XI.

Suppose that, by a back observation with a sextant, the lower limb of the sun's image was brought to the back horizon, and the angle shown by the index was 106° 12′, the altitude of the observer being twenty-two feet, and the correction for semidiameter, parallax, and dip. being (as usual) about 12′; required the true latitude, supposing the declination to be 20° S., and that the sun bore north at the time of observation.

Observed angle.............	106°	12′	
Dip and semidiam........add		12	
	106	24	
Subtract................. ..	90	00	
Zenith distance†............	16	24	S.
Sun's declination............	20	00	S.
Latitude..................	36	24	S.

We have observed, in the directions for finding the meridian altitude of an object, that an error will arise if the ship be in motion, or the sun's declination vary. The amount of this correction may be estimated in the following manner:—

Find the number of miles and tenths of a mile *northing* or *southing* made by the ship in one hour, and also the variation of the sun's declination in an hour, expressed also in miles and tenths. Add these together, if they both conspire to elevate or depress the sun; otherwise take their difference, which call the arc A. Find, in Table XXXII., the arc B, expressed in seconds, corresponding to the latitude and declination; then the arc A, divided by *twice* the arc B, will express the time in *minutes from noon*, when the greatest (or least) altitude is observed. Moreover, the square of the arc A, divided by four times the arc B, will be the number of *seconds* to be applied to the observed altitude to obtain the true altitude, which would have been observed if the ship had been at rest.

Thus, if the ship sail towards the sun south 11 miles per hour, and the declination increases northerly 1′ per hour, we shall have $A = 11 + 1 = 12$. If the latitude is 42° N., and the declination 2° S., we shall have by Table XXXII. $B = 2''$. In this case, the time from noon is $\frac{12}{4} = 3$ minutes, and the correction of altitude $\frac{144}{8} = 18$ seconds only.

* The declination of this star is given for every day in the Nautical Almanac; when great accuracy is required, this declination should be used instead of that in Table VIII.

† The refraction, being small, is neglected.

TO FIND THE LATITUDE BY A MERIDIAN ALTITUDE OF THE MOON.

THE latitude may be found at sea, by the moon's meridian altitude, more accurately than by any other method, except by the meridian altitude of the sun; but to do this, it is necessary to find the time of her passing the meridian, and her declination at that time. To facilitate these calculations, we have given the Tables XXVIII. and XXIX., the uses of which will evidently appear from the following rules and examples.

To find the mean time of the moon's passing the meridian.

Find, in the Nautical Almanac, the time of the moon's coming to the meridian of Greenwich for one day earlier than the sea account,* and also the time of her coming to the meridian of Greenwich the next day, when you are in west longitude, but the preceding day when in east longitude; take the difference between these times, with which you must enter the top column of Table XXVIII., and against the ship's longitude in the side column will be a number of minutes to be applied to the time taken from the Nautical Almanac, for the day immediately preceding the sea account, by adding when in west longitude, but subtracting when in east longitude; the sum or difference will be the mean time of passing the meridian of the given place.

EXAMPLE.

Required the time of the moon's passing the meridian of Philadelphia, April 19 1836, sea account.

The day preceding the sea account is April 18; on this day, the moon passed the meridian of Greenwich at $1^h\ 55^m.6$, and, being in west longitude, we find the time of her passing the meridian the next day $2^h\ 43^m.0$. The difference between these two times is $47^m.4$, which is to be found at the top of Table XXVIII.; the nearest tabular number is 48^m; under this, and opposite $75°$, (the longitude of Philadelphia,) is the correction 10^m, nearly, to be added to $1^h\ 55^m.6$, to obtain the time of passing the meridian at Philadelphia, April $19^d\ 2^h\ 05^m.6$, sea account, or April $18^d\ 2^h\ 05^m.6$, P. M., civil account.

To find the moon's declination when on the meridian.

Find the time of the moon's coming to the meridian as above; turn the ship's longitude into time by Table XXI.,† and add it thereto if in west longitude, but subtract it in east; the sum or difference will be the time at Greenwich. Take out the moon's declination from the Nautical Almanac, for the nearest hour preceding the Greenwich time,‡ and also the variation for 10 minutes in the next column.

* Taking the time one day earlier than the sea account, reduces it to astronomical time used in the Nautical Almanac. We may observe that the time of the moon's coming to the meridian, is given in the Nautical Almanac to tenths of a minute, instead of seconds of time. This is done to facilitate the calculation of the right ascension and declination, by using common decimal fractions instead of sexagesimals.

† Longitude may be turned into time, without the help of Table XXI., by multiplying the degrees and minutes of the longitude by 4, and considering the product as minutes and seconds of time respectively; and, by the inverse process of dividing by 4, we may turn time into degrees, &c. Thus $80° \times 4 = 320^m = 5^h\ 20^m$; and $15°\ 16' \times 4 = 61^m\ 04^s = 1^h\ 1^m\ 4^s$. In like manner, $1^h\ 20^m$ or 80^m, being divided by 4, gives $20°$, and 196^m, being divided by 4, gives $49°$, which agree with the table. If the ship be furnished with a chronometer, regulated for mean time at Greenwich, we may avoid the labor of this part of the operation by taking the time at Greenwich as shown by the chronometer, at the very moment when the meridian altitude of the moon is observed.

‡ If the time at Greenwich fall exactly upon any hour, the declination can then be taken from the Nautical Almanac, by mere inspection, without any reduction. We may also remark, that the reduction of the declination for the minutes and tenths of a minute of time, can be found by means of Table XXX.: but it is better to do it by the process of multiplication, as in the rule given above.

Digitized by Google

This variation is to be multiplied by the minutes and tenths of a minute which occur in the time at Greenwich; the product, being divided by 10, gives the correction of the declination taken from the Nautical Almanac, additive if that declination be increasing, subtractive if decreasing; the sum or difference will be the true declination at the time of passing the meridian.

NOTES.

1. By the above rule, the day of the month on which the moon passes the meridian must be taken one less than the sea account. When the longitude, turned into time, is added to the time of passing the meridian, and the hours of the same exceed 24^h, you must subtract 24^h, and add one to the day of the month; if the longitude be subtractive, and greater than the time of passing the meridian, you must, before the subtraction, add 24 hours to the time of passing the meridian, and subtract one from the day of the month; the sum or difference will be the time at Greenwich.

2. When the declination, taken from the Nautical Almanac for the nearest hour preceding the time at Greenwich, is decreasing, and the correction to be subtracted exceeds this declination, the difference of the two quantities will be the required declination, with a different name from that of the declination taken from the Nautical Almanac.

3. In the same manner we may find the declination for any other time of the day, by making use of the given time instead of the time of the moon's passing the meridian. In all these rules, the second differences of the moon's motion are neglected.

EXAMPLE.

Required the moon's declination at the time of her passing the meridian of Philadelphia, April 19, 1836, sea account.

The time of passing the meridian of Philadelphia was found, in the preceding example, to be April 19^d 2^h $5^m.6$ sea account, or April 18^d 2^h $5^m.6$ by astronomical account; adding this to the longitude of Philadelphia, in time 5^h 1^m nearly, we obtain the time at Greenwich, April 18^d 7^h $6^m.6$. The declination in the Nautical Almanac for April 18^d 7^h is 21° 13′ 52″ N., and the variation 89″ for 10 minutes of time nearly; multiplying this by $6^m.6$, and dividing by 10^m, we get 59″, to be added to 21° 13′ 52″, because the declination is increasing, and we obtain 21° 14′ 51″ N. for the required declination at the time of the moon's passing the meridian of Philadelphia.

To find the latitude by the moon's meridian altitude, obtained by a fore observation.

At the time of the moon's passing the meridian, the altitude of her round limb must be observed, whether it be the upper or lower limb. This altitude must be corrected for the semidiameter, dip, parallax, and refraction, in order to obtain the central altitude; with which, and the declination, we may find the latitude by the same rules as we have used in finding the latitude from the sun's meridian altitude. In making these calculations, we must find, from the Nautical Almanac, the moon's semidiameter and horizontal parallax, corresponding to the time of observation, reduced to the meridian of Greenwich, which was used in computing the declination. The moon's semidiameter is to be increased by the correction in Table XV., and this augmented semidiameter is to be added to the observed altitude, if the moon's lower limb be observed; but if the upper limb be observed, we must subtract this augmented semidiameter from the moon's observed altitude, to obtain the central altitude. From this central altitude you must subtract the dip of the horizon, found in Table XIII., to obtain the apparent altitude. The correction for parallax and refraction is likewise to be added; this correction is easily found by means of Table XIX., by subtracting the tabular number corresponding to the moon's altitude and horizontal parallax from 59′ 42″; the remainder will be the correction for parallax and refraction,* which is to be added to the apparent central altitude, to obtain the *true* altitude; and, by subtracting this true altitude from 90°, we obtain the *true* zenith distance. With this and the declination, we deduce the latitude by the usual rules, similar to those given for the sun in pages 166, 167.

* In computing this table, the *mean* refraction is used; but, when very great accuracy is required, the *true* refraction ought to be used. The corrections arising from this cause may be obtained from Table XXXVI., and are to be applied to the above-found zenith distance, with the same signs as in this table.

Digitized by Google

EXAMPLE I.

Suppose that, on the 27th of June, 1836, sea account, in the longitude of 80° W. from Greenwich, the meridian altitude of the moon's upper limb was observed to be 40° 0′, bearing south, the eye of the observer being elevated nineteen feet above the surface of the sea; required the true latitude.

June 27th, sea account, is June 26th by the Nautical Almanac; on this day the moon passes the meridian of Greenwich at 9ʰ 55ᵐ.9, mean time, and the next day at 10ʰ 59ᵐ.8, the daily difference being 63ᵐ.9. In Table XXVII., under 64ᵐ, (which is the nearest number in the table to 63ᵐ.9,) and opposite to the longitude 80°, stand 14ᵐ; adding this to 9ʰ 55ᵐ.9, we get 10ʰ 09ᵐ.9 for the time of passing the meridian at the place of observation.

☽ passes the merid.....June 26ᵈ	10ʰ	10ᵐ		
Ship's long. 80° W., in time,	5	20		
Time at Greenwich....June 26	15	30		
☽'s decli. June 26ᵈ 15ʰ	23°	37′	43″.2	S.
Cor. for 30ᵐ is 30×8″.798 +		4	23 .9	
Required declination....	23	42	07 .1	S.

Here the variation of the declination for 10ᵐ is, by the Nautical Almanac, 87″.98, or 8″.798 for 1ᵐ. Multiplying this by 30, we get the correction for 30ᵐ, equal to 263″.94, or 4′ 23″.9, as above. This is additive, because the declination is increasing. For the same time at Greenwich, we find ☽'s hor. par. 60′ 58″, and

☽'s semidiameter by N. A.,		16′	37″	
☽'s augmented semidiam.		16	47	
Alt. ☽'s upper limb.......	40	00	00	
☽'s semidiameter.....sub.		16	47	
☽'s central altitude.......	39	43	13	
Dip, T. XIII. for 19 feet, sub.		4	17	
☽'s apparent altitude.....	39	38	56	
59′ 42″				
Cor. T. XIX.—13 52 diff. add		45	50	
☽'s true altitude..........	40	24	46	
☽'s zenith distance.......	49	35	14	N
☽'s declination	23	42	07	S.
Latitude	25	53	07	N

EXAMPLE II.

Suppose that, on the 27th September, 1836, sea account, in the longitude of 90° E., the meridian altitude of the moon's lower limb was observed to be 50° 0′, bearing south, the eye of the observer being seventeen feet above the surface of the sea, required the true latitude.

Sept. 27th, sea account, is Sept. 26th, astronomical account; on this day the moon passed the meridian of Greenwich at 13ʰ 28ᵐ.0, and the preceding day at 12ʰ 42ᵐ.8, differing 45ᵐ.2. In Table XXVIII., under 46ᵐ, (which is the nearest tabular number,) and opposite to 90°, are 11ᵐ, which, being subtracted from 13ʰ 28ᵐ, leaves 13ʰ 17ᵐ for the time of passing the meridian of the place of observation. Subtracting the longitude 6ʰ, gives the corresponding time at Greenwich Sept. 26ᵈ 7ʰ 17ᵐ.

Sept. 26ᵈ 7ʰ, ☽'s declination by N. A...............	8°	47′	27″	N.
Cor. for 17ᵐ is 17×14″.482,		4	06	
Required declination.....	8	51	33	N.
☽'s hor. par. by N. A..........		56′	49″	
☽'s semidiam. by N. A.........		15	29	
☽'s aug. semidiam.............		15	41	

Obs. alt. ☽'s lower limb..	50°	00′	00″	
☽'s semidiam.........add		15	41	
☽'s central altitude......	50	15	41	
Dip, Ta. XIII., for 17 feet,		4	03	
☽'s apparent altitude.....	50	11	38	
59′ 42″				
Cor. T. XIX.—24 7 diff. add		35	35	
☽'s true altitude.........	50	47	13	
☽'s zenith distance.......	39	12	47	N
☽'s declination..........	8	51	33	N
Latitude................	48	04	20	N.

The latitude may also be obtained from the moon's meridian altitude, by the following approximative method, which will vary but very little from the truth, except when the horizontal parallax and semidiameter are very large or very small:—

Abridged approximative method of finding the latitude by the moon's meridian altitude, obtained by a fore observation.

To the observed altitude of the moon's lower limb add 12′; but if her upper limb be observed, subtract 20′. With this corrected altitude enter Table XXIX., and

Digitized by Google

take out the corresponding number of minutes, which are to be added to the corrected altitude; the sum will be nearly equal to the true altitude of the moon; its complement is the zenith distance, which is to be used, as before, with the moon's declination, in finding the latitude, as by a meridian altitude of the sun.

EXAMPLE III.

Suppose that, on the 29th of November, 1836, sea account, in the longitude of 150° W., the meridian altitude of the moon's upper limb was observed 60° 26', bearing north; required the true latitude.

Nov. 29th, sea account, is Nov. 28th by the Nautical Almanac; on this day the moon passed the meridian of Greenwich at $16^h\ 33^m.1$, and the next day at $17^h\ 18^m.6$, differing $45^m.5$. In Table XXVIII., under 46^m, (the nearest tabular number,) and opposite the longitude 150°, stands 19^m; adding this to $16^h\ 33^m$, we get $16^h\ 52^m$ for the time of passing the meridian of the place of observation nearly.

☽ passes the meridian.....	$28^d\ 16^h\ 52^m$
Long. 150° W., in time.....	10 00
Time at Greenwich....Nov.	29 02 52
☽'s dec., Nov. 29^d, 2^h....	20° 41' 06" N.
Cor. for 52^m is $52 \times 9''.6$,	— 8 19
Required declination....	20 32 47 N.

Obs. alt. ☽'s upper limb......	60° 26'
Subtract..................	20
Apparent altitude...........	60 06
Cor. Table XXIX.......add	28
☽'s true altitude.......	60 34
☽'s zenith distance..........	29 26 S.
☽'s declination	20 33 N
Latitude....................	8 53 S

In this example, the moon's horizontal parallax is 54' 23"; with this, and the altitude 60° 6' we find the correction in Table XIX. is 33' 8"; subtracting this from 59' 42", we get the correction of altitude 26' 34", instead of 28' found above from Table XXIX., making the corrected latitude 8° 54' 26" S.

We shall now work Examples I. and II. by this approximative method.

EXAMPLE IV.

[Same as Example I.]

Alt. ☽'s upper limb	40° 00'
Subtract..................	20
☽'s central altitude..........	39 40
Cor. Table XXIX........add	43
☽'s true altitude.......	40 23
☽'s zenith distance..........	49 37 N.
☽'s declination.............	23 42 S

EXAMPLE V.

[Same as Example II.]

Alt. ☽'s lower limb.........	50° 00'
Add	12
☽'s central altitude..........	50 12
Cor. Table XXIX........add	36
☽'s true altitude............	50 48
☽'s zenith distance..........	39 12 N
☽'s declination.............	8 52 N

TO FIND THE LATITUDE BY A MERIDIAN ALTITUDE OF A PLANET.

THE latitude may frequently be obtained, with great accuracy, (particularly in the morning and evening, when the horizon is well defined,) by observing the meridian altitude of Venus, Mars, Jupiter, or Saturn. From these altitudes we may find the latitude by similar methods to those we have already given for the sun. The times of passing the meridian of Greenwich, and the declinations of these planets, are inserted in the Nautical Almanac, at every noon, at Greenwich; and, as the daily variations of these quantities are small, we can find, by inspection, to a sufficient degree of exactness for most nautical purposes, the corresponding times of transit and declinations at the place of observation, and thence the latitude, as in the following rule:—

RULE.

Find, in the Nautical Almanac, the time of passing the meridian cn the day nearest to that in which the observation is made; this will be nearly the time of passing the meridian at the place of observation.* Turn the ship's longitude into time, and add it to the time of passing the meridian, when in west longitude, but subtract it in east; the sum or difference will be the time at Greenwich, nearly.† Take, from the Nautical Almanac, the planet's declination for the noon immediately preceding, and for that immediately following, the time of observation, and note the difference of the declinations when they are of the same name, but their sum when of different names; this sum or difference will be the daily variation of declination. Then say, As 24 hours are to the daily variation of declination, so are the hours and minutes of the time at Greenwich to the correction of the declination; to be applied to the first declination taken from the Nautical Almanac, additive if the declination be increasing, subtractive if decreasing; the sum or difference will be the declination of the planet at the time of observation. But you must observe that, if the correction of declination be greater than the declination first marked in the Nautical Almanac, their difference will be the sought declination, which will be of a different name from the first declination.

From the observed altitude of the planet, taken by a fore observation, subtract the refraction and dip, the latter being, in general, about 4′. The remainder, being subtracted from 90°, will give the true zenith distance nearly,‡ with which, and the declination, we may find the latitude, as by an observation of the sun.

EXAMPLE I.

Suppose that, on the 23d of October, 1836, sea account, in the longitude of 65° W., Jupiter passed the meridian to the southward; the meridian altitude of his centre, being observed, was 45° 20′, and the dip 4′; required the true latitude.

Oct. 23d, sea account, is Oct. 22d by the Nautical Almanac; and on that day Jupiter passed the meridian at $19^h\ 5^m$, nearly; adding the longitude 65°, turned into

* If we wish to find the time of passing the meridian more accurately, we must take a proportional part of the difference of the times of coming to the meridian given in the Nautical Almanac, in like manner as in finding the declination of the planet; always keeping in mind, that the time, according to the astronomical computation, is used in the Nautical Almanac, and is one day less than the sea account.

† This part of the operation may be avoided, if we have a chronometer regulated for Greenwich time, and note by it the time of observation.

‡ To be strictly accurate, we ought to subtract the parallax in altitude from this zenith distance. This is found in Table X. A. Thus, if the horizontal parallax of the planet be 20″, and the altitude 60°, the parallax in altitude by this table is 10″, to be added to the observed altitude, or subtracted from the observed zenith distance. The centre of the planet being observed there is no correction for the semidiameter of the planet

Digitized by Google

time, (that is, $4^h\ 20^m$,) we get the corresponding time at Greenwich, by the Nautical Almanac, Oct. $22^d\ 23^h\ 25^m$; and, for this time, we find the declination of the planet, by mere inspection of the Nautical Almanac, to be 16° 45′ N., nearly.

From Jupiter's observed altitude	45° 20′	
Subtract dip 4′, refraction 1′	5	
Leaves the true altitude	45 15	
Whence the true zenith distance is	44 45	N.
Jupiter's declination	16 45	N.
Latitude	61 30	N.

In this example we have found, by inspection, the time of passing the meridian, or the declination. If greater accuracy is required, we must take proportional parts of the daily variations, corresponding to the longitude of the place, and the time of observation. Thus, the time of passing the meridian on Oct. 22, by the Nautical Almanac, is $19^h\ 5^m.4$, and on Oct. 23 is $19^h\ 2^m.0$, decreasing $3^m.4$ daily, or for 360° of longitude. Then, by proportion, we have $360° : 3^m.4 :: 65° : 0^m.6$; so that the correction of the time of passing the meridian for 65° W. longitude is $0^m.6$, to be subtracted from $19^h\ 5^m.4$, to obtain the time of passing the meridian in the place of observation, $19^h\ 4^m.8$. Adding to this the longitude, turned into time, $4^h\ 20^m$, we get the corresponding time at Greenwich, $22^d\ 23^h\ 24^m.8$. Now, by the Nautical Almanac, the declination, Oct. 22d, is 16° 47′ 17″.2 N., at noon, and the next day, 16° 45′ 18″.1 N., at noon, differing 1′ 59″.1, or 119″.1. Then say, As $24^h : 119''.1 :: 23^h\ 24^m.8 : 116''$ or 1′ 56″, to be subtracted from 16° 47′ 17″.2, to obtain the true declination, 16° 45′ 21″ nearly, at the time of observation. The horizontal parallax, by the Nautical Almanac, is 1″.56, which is wholly insensible; and the semidiameter is 18″, which must be neglected because the central altitude was observed. Hence we see that these corrections in the calculations produce but very little change in the resulting latitude, and that the process by inspection is sufficiently accurate; and this will be found generally to be the case with the planets Jupiter and Saturn.

EXAMPLE II.

Suppose that, on the 17th of September, 1836, sea account, in the longitude of 75° E., Venus passed the meridian to the northward; the meridian central altitude, being observed, was 26°, and the dip 4′; required the true latitude.

Sept. 17th, by sea account, is Sept. 16th by the Nautical Almanac; and on this day Venus passed the meridian at $20^h\ 59^m$, nearly; subtracting the longitude $75° = 5^h$, we get Sept. $16^d\ 15^h\ 59^m$ for the corresponding time at Greenwich. Now, by the Nautical Almanac, the declination of Venus, at noon, Sept. 16^d, was 14° 49′ 33″.7 N., and the next day 14° 44′ 22″.1 N., differing 5′ 11″.6. Then we have $24^h : 5' 11''.6 :: 15^h\ 59^m : 3' 27''.5$; subtracting this from 14° 49′ 33″.7, we get 14° 46′ 06″ N., nearly, for the planet's declination at the time of observation.

From the observed central altitude of Venus	26° 00′	
Subtract dip 4′, refraction 2′	6	
Leaves the true altitude nearly	25 54	
Whence the true zenith distance is	64 06	S.
Declination of Venus	14 46	N.
Latitude	49 20	S.

Digitized by Google

TO FIND THE LATITUDE BY DOUBLE ALTITUDES

FORM I.—*By double altitudes of the sun.*

WHEN (by reason of clouds, or from other causes) a meridian altitude cannot be obtained, the latitude may be found by two altitudes of the sun, taken at any time of the day, the interval or elapsed time between the observations being measured by a good watch or chronometer, noticing the seconds, if possible, or estimating the times to a third or a quarter of a minute, if the watch is not furnished with a second-hand. The observed altitudes of the sun must be corrected, as usual, for the semidiameter, dip, refraction, and parallax, in the same manner as in finding the latitude by a meridian altitude. When great accuracy is required, the declination must be found at the time of each observation, using the *third* method of solution hereafter given; but when the sun's declination varies slowly, or the elapsed time is small, it will in general be sufficiently accurate to find the sun's declination for the *middle time between two observations*, and to consider it as invariable during the observations, computing the latitude by the first or second method.

This manner of finding the latitude is, in general, most to be depended upon where the sun's meridian zenith distance is great. If the sun passes the meridian near to he zenith, much greater care must be taken in measuring the altitudes and noting the times, than would be necessary under other circumstances. The nearer the sun is to the meridian, at the time of one of the observations, the more correct the result will commonly be. In general, the elapsed time ought to be as great, or greater, than the time of the nearest observations from noon. Similar remarks may be made upon every one of the following forms.

In all these observations it is supposed that the watch moves uniformly according to *apparent* time, measuring twenty-four hours from the time of the sun's passing the meridian on two successive days at the same place of observation. If the watch gain or lose on apparent time, supposing the observer to be at rest, a correction must be applied for the gain or loss during the time elapsed between the observations, so as to obtain accurately the *elapsed time* or *hour angle*. It is not required that the watch should be regulated so as to give precisely the *hour* of observation; the only thing required is to find the *elapsed time* with all possible accuracy.

FORM II.—*Double altitudes of a star.*

Double altitudes of a fixed star may be used in finding the latitude, and the calculation is almost identical with that of double altitudes of the sun; the only difference consists in adding a small correction to the elapsed mean solar time between the observations, on account of the daily acceleration of 3′ 56″ in the time a star comes to the meridian on successive days; in other words, the *elapsed time* (or *hour angle*) must be reckoned in sideral time, of which we have already spoken in the second note on page 147. Now, as a chronometer is usually adjusted to mean solar time, and the observations marked by it, we must add to the mean time, elapsed between the observations, the correction given in Table LI., to reduce it to sideral time. Thus, if the interval in mean solar time be 3^h, the corresponding correction in this table is $+ 29^s.6$, making the interval in sideral time (or the correct *hour angle*) $3^h\ 00^m\ 29^s.6$, which is to be used in the rest of the calculation.

In observations of a fixed star, the altitudes are to be corrected for dip and refraction, as in finding the latitude by a meridian altitude. The declination of the star is to be found in Table VIII.* With these altitudes, the declination, and the hour

* Or more accurately in the Nautical Almanac, if any one of the bright stars is observed whose place is given in that work.

Digitized by Google

angle, the calculation is to be made by either of the three methods hereafter given.

The chief difficulty, in observations of this kind, with a fixed star, is the want of a good horizon in the night-time. The method, however, might sometimes be used with success, soon after the dawn of day, or late in the evening twilight, at a time when the horizon is well defined, and the star sufficiently bright to bring its reflected image to the horizon. Sometimes a good horizon is produced by the aurora borealis, in which case a good observation might be made with stars in the northern horizon; but a single observation of the polar star will answer the same purpose, and will be much more simple.

FORM III.—*Double altitudes of a planet.*

Double altitudes of a planet (particularly Jupiter and Venus, on account of their great brightness) may sometimes be used with success. The observed altitudes must be corrected for dip and refraction. The parallax and semidiameter, being small, may be neglected, except in cases where extreme accuracy is required. The declination of the planet is to be found, in the Nautical Almanac, for the supposed time at Greenwich. The daily variation of the time of coming to the meridian is also to be found in the same page; and thus the time elapsed between the passage of the planet over the meridian on two successive days is found; then the corrected elapsed time, or *hour angle*, is obtained by the following rule:—

RULE. *As the interval of time between two successive passages of the object over the meridian is to twenty-four hours, so is the elapsed mean time between the observations to the corrected elapsed time, or hour angle.*

With this *hour angle*, the *declination*, and *corrected altitudes*, the latitude may be found by either of the *three* following methods of calculation

FORM IV.—*Double altitudes of the moon.*

Double altitudes of the moon may also be used in finding the latitude. These observations may be easily and very accurately made; but the calculation is much more complex than any of the preceding methods, on account of the great change in the moon's declination and right ascension during the elapsed time between the observations. If, however, by the times of observation, and the longitude of the ship, (or else by a chronometer,) the time at Greenwich can be obtained within a few minutes, we may, from the Nautical Almanac, find the corresponding declination, semidiameter and horizontal parallax of the moon for *each* of these observations. With the horizontal parallax, and the moon's apparent altitude, find the correction in Table XIX., which, being subtracted from 59′ 42″, leaves the correction of the moon's altitude for parallax and refraction;* this is to be added to the corresponding observed altitude, corrected for semidiameter and dip, to obtain the moon's *correct* central altitude. This is to be done at *each* observation. Lastly, the time of the moon's passing the meridian on successive days, given in the Nautical Almanac, shows the interval of time between two successive passages of the moon over the meridian,† and *this time is to twenty-four hours as the elapsed time between the observations is to the corrected elapsed time or hour angle.* With this hour angle, the correct central altitudes, and the declinations, the latitude may be found by the fourth of the following methods of calculation, it being very rare that the other methods can be used, on account of the great change in the moon's declination.

FORM V.—*By altitudes of two different objects, taken at the same time.*

The latitude may be obtained by observing, at the *same moment of time*, the altitudes of two heavenly bodies; as, for example, (1) The sun and moon;‡ (2) The moon and a fixed star or planet;‡ (3) A planet and a fixed star; (4) Two planets; (5) Two fixed

* When extreme accuracy is not required, we may find the correction for parallax and refraction from Table XXIX., which, if the altitudes are large, will not vary much from the truth.

† This time is given to tenths of a minute, which in general is sufficient, because, if the elapsed time be small, the effect of this correction will be only a few seconds. It might be obtained more accurately by means of the right ascensions of the sun and moon, using the second differences, as taught in the Appendix.

‡ A particular case of this method occurs in taking a lunar observation, which will be treated of separately, because, the distance of the two bodies being known, the calculation becomes more simple.

Digitized by Google

stars. In these methods the altitudes are to be corrected, as in the preceding *Forms*, for dip and refraction; also for parallax and semidiameter when necessary, as is always the case in observations of the moon and sun. The declinations of the bodies are to be found for the supposed time of observation, reduced to the meridian of Greenwich, by means of the Nautical Almanac, or by Table VIII. for the fixed stars, as before taught. Then the difference of the right ascensions of the bodies (or that difference subtracted from 24 hours, if it exceed 12 hours) will be the *hour angle*, which is to be used, with these declinations and corrected altitudes, in finding the latitude, by either of the three first methods, if the declinations should be equal, or differ but one or two minutes; otherwise by the fourth method, which, in fact, may be considered as the only method to be used in this kind of observations, because, in almost all cases, the declinations of the objects differ considerably.

FORM VI.—*By altitudes of two different objects, taken within a few minutes of each other, by one observer.*

It may sometimes happen, for want of *two* good instruments, or from not having *two* observers, that the preceding Form V. cannot be employed. In this case the whole of the observations may be made by one person, noticing the interval between the observations, and making the calculation as in the following Form VII. But it is in general much better to make the observations as near to each other as possible, and then, by a very simple process, the calculation may be reduced to that of Form V., in which the observations are taken *at the same moment*. This is done by observing the *first object* twice, *before* and *after* observing the *second object*. For if the intervals of time between these three observations be equal, (as, for example, one minute, or two minutes,) the half-sum of the two altitudes of the first object may be taken for the altitude corresponding to the time of observing the second altitude, and the calculation may then be made as in Form V. Thus, suppose at $10^h\ 2^m$, A. M., per watch, the altitude of Sirius was 17° 54′, at $10^h\ 4^m$ per watch the altitude of Capella 60° 45′, and at $10^h\ 6^m$ per watch the altitude of Sirius was again observed and found to be 17° 58′. In this case, the intervals of time are exactly two minutes; therefore the half-sum of the altitudes of Sirius is to be taken 17° 56′, and combined with the altitude of Capella 60° 45′, supposing *both* to have been observed at $10^h\ 4^m$ per watch. This is the most simple form in which an observation of this kind can be made by one observer.

If, from any cause whatever, the observations cannot be taken at exactly equal intervals, the altitude of the first object, at the time of observing the second object, may be found by proportion, supposing the altitudes to vary uniformly during the few minutes of the observations. Thus, in the preceding example, suppose the altitudes and the two first-noted times to remain unaltered, but the last observation of Sirius to have been at $10^h\ 10^m$ per watch, instead of $10^h\ 6^m$. In this case, during the eight minutes of time elapsed between $10^h\ 2^m$ and $10^h\ 10^m$, Sirius would have risen 4′, (from 17° 54′ to 17° 58′;) therefore, by proportion, it is found that in two minutes (the time elapsed between $10^h\ 2^m$ and $10^h\ 4^m$) the star would have risen 1′, and the altitude would have increased from 17° 54′ to 17° 55′; therefore, at the time $10^h\ 4^m$ per watch, the altitude of Sirius must be taken at 17° 55′, the altitude of Capella 60° 45′, and with these quantities, considered as observed at this last-mentioned time $10^h\ 4^m$, the calculation must be made as in Form V.

There are several advantages attending these two last forms V., VI., since no allowance is necessary for the change of place of the ship; the observations can be immediately made, in a short interval of fair weather, when the common method of double altitudes might fail from the intervention of clouds; the time can also be obtained at the same operation, &c.

FORM VII.—*By altitudes of two different objects, taken at different times.*

This method differs but very little from the two last. The altitudes are to be corrected, in the same manner, for dip and refraction; also for parallax and semidiameter, when necessary. The right ascension and declination of *each* object is to be found for the supposed time of observing *that* object reduced to the meridian of Greenwich. Then the apparent elapsed time between the observations, is to be turned into sideral time, which may be done, as in Form II., by adding the correction in Table LI. corresponding to this time; add this sidereal time to the right ascension of the body first observed; the difference between this sum and the right ascension of the body last observed is the *hour angle*.* This, with the

* If this difference exceed 12 hours, subtract it from 24 hours, and use the remainder as in Form V.

declinations and corrected altitudes, is to be used in finding the latitude by the *third* or *fourth* of the following methods of calculation, it being very rarely the case that the first or second methods can be used, on account of the difference of the declinations. These three last forms, when a fixed star or planet is used, are restricted very much from the want of a good horizon in the night; they are best adapted to the morning and evening twilight.

GENERAL REMARKS.

Having thus explained several of the different *forms* of making these observations, and the manner of finding in each form the *hour angle*, the *declinations*, and the *correct central altitudes*, we shall now give four different methods of calculating the latitude, and shall illustrate the rules by proper examples. In the *first* and *second* methods, the declination is supposed to be the *same* at both observations, which is true as it respects observations of a fixed star, and is in general sufficiently correct for common observations of double altitudes of the sun. The first of these methods is direct and simple not embarrassed with much variety of cases, requiring only ten openings of the Table XXVII., without any halving or doubling of the logarithms, or the use of natural or versed sines. This method is in fact nearly, if not fully, as short as the *second* or approximative method invented by Mr. Douwes, and which was exclusively used in the former editions of this work. This *second* (or Douwes') method is liable to the objection that the calculation must sometimes be repeated several times before a true solution can be obtained, and then it becomes extremely troublesome. This difficulty does not occur in the first method; and on this account, as well as for its remarkable simplicity, the first method is always to be preferred.

The *third* method is applicable to cases where there is a small variation in the declination of the object, during the elapsed time between the observations, as most commonly happens when the sun is used. This method is short and simple, and is much facilitated by the use of Table XLVI., which I have computed.

The *fourth* method embraces the general solution of the problem in the case where any variation whatever of declination is noticed. This increases the labor considerably, and renders the solution more complex in its cases. It is, however, believed, that this method, drawn up in its present form by the author of this work, will be easily understood by navigators, and that they will thus be enabled to determine the latitude with considerable accuracy in cases where it might be of the utmost importance to know it, and where other methods could not be resorted to on account of bad weather. This method is nearly, if not quite, as short as that published by Dr. Brinkley in the Nautical Almanac of 1825, and does not require, like his method, a second or third (or even a greater number) of operations.

If the observer should change his place or station, during the elapsed time between the observations, a correction must be applied to one of the altitudes on this account. The manner of doing this is shown in the following examples.

It may be observed that in like manner as there are two latitudes corresponding to the *same* meridian altitude of the sun, according as the zenith is north or south of the sun when on the meridian, so in double altitudes there are generally two latitudes, corresponding to the proposed altitudes, according as the zenith and north pole are on the same side, or on different sides, of the *arc* or *great circle* passing through the two observed bodies, or through the two places of the same body; and it therefore becomes necessary to notice, at the time of observation, how the zenith and north pole are situated with respect to this great circle.

To estimate the effect of small errors in the observations

When running in with the land, or crossing a dangerous parallel with no other means of obtaining the latitude than by double altitudes, it becomes a matter of great importance to ascertain the possible error of the latitude thus computed, arising from supposed errors in the observed altitudes, or in the elapsed time. The differential expressions in spherical trigonometry afford methods of doing this; but they are not adapted to the nature of this work, on account of the complication and variety of cases. The following method, though long, is general and infallible, and was once used by the writer in a case of great anxiety and danger.

Rule. After having computed the latitude by either of the four following methods, using the observed altitudes* and elapsed time, *repeat the operation*, varying

* That is, the observed altitudes, corrected as usual for dip, refraction, parallax, and semidiameter if necessary.

Digitized by Google

the altitude you suspect may be erroneous by 2′ or 3′, (or whatever you suppose the limit of the error in that altitude may be;) the difference between this *second* latitude and that first computed, is the effect of the supposed error in that altitude. If you suspect the second altitude also to be erroneous, the operation may be again repeated, varying this second altitude 2′ or 3′, (or whatever the limit may be supposed,) but using the first observed altitude and elapsed time; comparing this *third* computed latitude with the *first*, the difference is the effect of this supposed error in the *second* altitude. Finally, if the elapsed time is supposed to be erroneous, the operation may be again repeated, using the observed altitudes and varying the elapsed time by 20 or 30 seconds, (or whatever the limit of this error may be supposed;) the difference between this *fourth* latitude and that *first* computed is the effect of this supposed error of the elapsed time.

Thus, suppose the first-computed latitude was 30°, the second 30° 1′, the third 30° 3′, the fourth 30° 2′; the error arising from the first altitude would be 1′, that from the second altitude 3′, and that from the elapsed time 2′. If all these errors existed at the same time, the greatest limit of the error would be the sum of these quantities (or 6′), so that the true latitude would be 30° ± 6′, or between 29° 54′ and 30° 6′. In this way the limit of the error may be obtained in any case, and the degree of confidence that may be placed in the observation obtained. This examination is sometimes very necessary, because the objects may be so situated, that a small error in the observations might produce a considerable change in the computed latitude. It may be observed that the error of one observation is frequently corrected, in whole or in part, by the error of the other; the one tending to increase the latitude, the other to decrease it.

FIRST METHOD.

To find the latitude by double altitudes of the sun, or any other object, the declination being invariable.

In this method, the log. sines, cosines, &c., of Table XXVII. are used; and, for brevity, the word log. is omitted in the rule. For the convenience of writing down at once, in the same line, all the logarithms which occur at the same opening of the book, they are arranged in three columns, as in the following formula; and it will be very convenient to have one of these blanks prepared at the commencement of the operation, and then the logarithms may be written down, in their proper places, with great rapidity.

FORMULA.

Col. 1.	Col. 2.	Col. 3.
Elapsed time, [P. M.] Cosec.		
Declination ....Secant ____	....	....Cosec.
A ....Cosec.	Cosine	..........Cosine ____
Half-sum alts.......Cosine	Cosec.	B Cosec. ____
Half-diff. alts........ Sine ____	Sec.	[B less than 90°, like declination N. or S.]
C ....Sine ____	Cosine ____	..........Cosine
[Z less than 90° north or south, like the bearing of zenith.]	Sec. ____	Z ____
[E is the *sum* of B, Z, if of the *same* name; *difference*, if of a *different* name.]		E ____ Sine ____
	Latitude	Sine ____

RULE. (*Using Table* XXVII.)

1. Find the elapsed time * in column P. M.; take out the corresponding cosecant, and put it in Col. 1.

2. Put the secant of the declination in Col. 1; its cosecant in Col. 3.

3. The sum of the logarithms in Col. 1 (rejecting 10 in the index) is the cosecant of the angle A, whose cosine is to be put in Col. 2 and Col. 3.†

4. The sum of the logarithms in Col. 3 (rejecting 10 in the index) is the cosecant of the angle B, (less than 90°,) which is to be named *north* or *south*, like the declination.

* If any other object than the sun is observed, the *corrected* elapsed time, or *hour angle*, found as before taught, is to be used.

† The cosines of A and C are each written down *twice*, which reduces the number of logarithms in each example from 17 to 15.

Digitized by Google

5. Find half the *sum* of the two altitudes; place its cosine in Col. 1, its cosecant in Col. 2. Find also half the difference of the two altitudes; place its sine in Col. 1, its secant in Col. 2.

6. The sum of the three lower logarithms of Col. 1 (rejecting 20 in the index) is the sine of the angle C, whose cosine is to be placed in Col. 2 and Col. 3.*

7. The sum of the logarithms in Col. 2 (rejecting 30 in the index) is the secant of the zenith angle Z, which is to be taken out (less than 90°) and placed under B, in Col. 3, naming it *north* if the zenith and north pole be situated on the *same* side of the arc or great circle passing through the two observed places (or objects), but *south* if the zenith and north pole be situated on *different* sides of that great circle.†

8. The angle E is found by taking the *sum* of the angles B, Z, if they are of the *same* name, or their *difference* if of *different* names, marking E *north* or *south*, like the greatest of the two angles B or Z.‡

9. Put the sine of E in Col. 3, and the sum of the two last-written logarithms of Col. 3 (rejecting 10 in the index) is the sine of the latitude, of the same name as E.

If the time of observation were required, it might be found by the following rule, still using Table XXVII.:—

RULE. Add the tangent of C to the secant of E; the sum (rejecting 10 in the index) is the tangent of an angle. Take out half the corresponding time in Col. P. M., (or in Col. A. M., increased by 12 hours,) and this will represent the horary distance of the object from the meridian (upper or lower) at the middle time between the two observations. Take the sum and difference between this and half the elapsed time, or hour angle, and they will be the hours and minutes distance from the meridian corresponding to both observations, expressed in apparent solar time if the sun be observed, sideral time if a star is observed, &c.

EXAMPLE I.

Being at sea, in latitude 46° 30′ N. by account, when the sun's declination was 11° 17′ N. at $10^h\ 2^m$ per watch, in the forenoon, the sun's correct central altitude was 46° 55′, and, at $11^h\ 27^m$, per watch, in the forenoon, the correct central altitude was 54° 9′; required the true latitude.

Subtracting $10^h\ 2^m$ from $11^h\ 27^m$ gives the elapsed time $1^h\ 25^m$.

COL. 1.	COL. 2.	COL. 3.
El. time [P.M.] $1^h\ 25^m$, Cosec. 10.73429		
Declination 11° 17′ N. Sec. 10.00848		..........................Cosec. 10.70850
A..................Cosec. 10.74277	Cosine 9.99278	.........Cosine 9.99278
½ sum alts. 50 32 ..Cosine 9.80320	Cosec. 10.11239	B 11° 28′ N. Cosec. 10.70128
½ diff. alts. 3 37 ...Sine 8.79990	Secant 10.00087	[B less than 90°, named N. or S. like declin.]
C............. ....Sine 9.34587	Cosine 9.98905	.........Cosine 9.98905
[Z less than 90°, and N. or S. like bearing of zenith.]	Secant 10.09509	Z 36 33 N.
[E is the *sum* of B, Z, if of the *same* name; *difference* if of a *different* name.]		E 48 01 N. Sine 9.87119
		Latitude 46 27 N. Sine 9.86024

If the sun had passed the meridian to the north of the observer, Z would have been 36° 33′ S., and E = 25° 5′ S., whose sine 9.62730, added to cos. C 9.98905, gives the sine of the latitude 9.61635, corresponding to 24° 25′ S.

In the first case, (in north latitude,) the tangent of C 9.35682, added to the secant E 10.17463, gives 9.53145, which, in the tangents, corresponds to $2^h\ 30^m\ 12^s$, nearly, whose half, $1^h\ 15^m\ 6^s$, is the time of the middle observation from noon; adding and subtracting half the elapsed time, $42^m\ 30^s$, gives the times of the observations from noon $1^h\ 57^m\ 36^s$ and $0^h\ 32^m\ 36^s$.

* The cosines of A and C are each written down *twice*, which reduces the number of logarithms in each example from 17 to 15.

† In observations of the sun, the angle Z may in general be called *north*, if the zenith be *north* of the sun when on the meridian at its greatest altitude; but *south* if the zenith be then *south* of the sun When the object passes the meridian near the zenith, it may be doubtful whether it be *north* or *south*, in which case the latitude may be computed upon both suppositions, and that one selected which agrees best with the estimated place of the ship; and this extra labor is very small. But observations on an object passing near the zenith are liable to great errors, and had better be rejected.

‡ This case is easily remembered, because *s* is the first letter of *same* and *sum*, and *d* the first lette of *different* and *difference*.

Digitized by Google

EXAMPLE II.

At sea, in the latitude of 47° 19′ N. by account, when the sun's declination was 12° 16′ N., at 10^h 24^m A. M., per watch, the sun's correct central altitude was 49° 9′; at 1^h 14^m P. M., per watch, his correct central altitude was 51° 59′; required the latitude.

Subtracting 10^h 24^m from 1^h 14^m increased by 12^h, leaves the elapsed time 2^h 50^m.

Col. 1.		Col. 2.		Col. 3.	
El. time [P.M.] 2^h 50^m, Cosec.	10.44077				
Declination 12° 16′ N. Sec.	10.01003	....		Cosec.	10.67272
A.................Cosec.	10.45080	Cosine	9.97089	........Cosine	9.97089
½ sum alts. 50 34 ..Cosine	9.80290	Cosec.	10.11218	B 13°08′ N. Cosec.	10.64361
½ diff. alts. 1 25 ....Sine	8.39310	Secant	10.00013	[B less than 90°, named N. or S. like declin.]	
C.................Sine	8.64680	Cosine	9.99958	... .Cosine	9.99958
[Z less than 90° and N. or S., like bearing of zenith.]		Secant	10.08278	Z 34 16 N.	
[E is the *sum* of B, Z, if of the *same* name; *difference* if of a *different* name.]				E 47 24 N. Sine	9.86694
				Latitude 47 20 N. Sine	9.86652

If the sun had passed the meridian to the north of the observer, Z would have been 34° 16′ S., E = 21° 08′ S.; its sine 9.55695, added to cosine C 9.99958, gives 9.55653, the sine of the latitude 21° 7′ S.

If the observed object, in this example, had been a fixed star, with the same declination 12° 16′ N., the same altitudes 49° 9′, 51° 59′, but the elapsed time 2^h 49^m 32^s, the calculation would have been exactly as above. For, by adding, according to the rule in page 176, the correction in Table LI., 28^s, to reduce it to sideral time, we shall obtain the corrected elapsed time, or hour angle, 2^h 50^m, and every part of the work will be as above.

If the planet Venus had been observed, at the same corrected altitudes, on the 13th of March, 1836, in a place where his declination at the middle time between the two observations was, by the Nautical Almanac, 12° 16′ N., and the elapsed time 2^h 50^m $03^s.5$, the calculation would still be the same. For, by the Nautical Almanac, it appears that Venus passes the meridian on the 13th and 14th of March, at 2^h 27^m 12^s and 2^h 27^m 42^s respectively, increasing 30^s, so that the interval of two successive transits is 24^h 00^m 30^s. Then saying, As this interval is to 24^h, so is the elapsed time 2^h 50^m $03^s.5$ to the corrected elapsed time, or *hour angle*, 2^h 50^m 00^s, which is to be used as above, all the rest of the work being the same. We may proceed in the same manner, if the moon be observed at a time when the declination varies but little.

EXAMPLE III.

Being at sea, in latitude 50° 40′ N. by account, when the sun's declination was 20° 0′ S. at 10^h 17^m A. M., per watch, the sun's correct central altitude was found to be 17° 13′, at 11^h 17^m, per watch, the correct central altitude was found to be 19° 41′; required the latitude.

Subtracting 10^h 17^m from 11^h 17^m, gives the elapsed time 1^h.

Col. 1.		Col. 2.		Col. 3.	
El. time [P.M.] 1^h 0^m, Cosec.	10.88430				
Declination 20° 00′ S. Sec.	10.02701	....		Cosec.	10.46595
A................Cosec.	10.91131	Cosine	9.99670	..........Cosine	9.99670
½ sum alts. 18 27 Cosine	9.97708	Cosec.	10.49966	B 20°10′ S. Cosec.	10.46265
½ diff. alts. 1 14 ...Sine	8.33292	Secant	10.00010	[B less than 90°, named N. or S. like declin.]	
C................Sine	9.22131	Cosine	9.99390	..........Cosine	9.99390
[Z less than 90°, and N. or S. like bearing of zenith.]		Secant	10.49036	Z 71 08 N.	
[E is the sum of B, Z, if of the same name; *difference*, if of a *different* name.]				E 50 58 N. Sine	9.89030
				Latitude 50 00 N. Sine	9.88420

Digitized by Google

If the sun had passed the meridian to the north of the observer, Z would have been 71° 08′ S., and E = 91° 18′ S., whose sine 9.99989, added to 9.99390, gives the sine of the latitude 9.99379, corresponding to 80° 20′ S.

EXAMPLE IV.

Being at sea, in the latitude of 60° 0′ N. by account, when the sun was on the equator (or had no declination) at 1h 0m P. M., per watch, his correct central altitude was 28° 53′, and at 3h 0m P. M., per watch, the correct central altitude was 20° 42′, required the true latitude.

Col. 1.		Col. 2.		Col. 3.	
El. time [P.M.] 2h 0m, Cosec.	10.58700				
Declination 0......Secant	10.00000	....			[Cosec. *Infinite.*]
A.........15° 00′ Cosec.	10.58700	Cosine	9.98494	....	[Cosine 9.98494]
½ sum alts. 24 47½ Cosine	9.95801	Cosec.	10.37745	B 00° 00′	[Cosec. *Infinite.*]
½ diff. alts. 4 5½ Sine	8.85340	Secant	10.00110		[B less than 90°, named N. or S. like declin.]
C..................Sine	9.39841	Cosine	9.98594	....	Cosine 9.98594
[Z less than 90°, and N. or S. like bearing of zenith.]		Secant	10.34943	Z 63 26 N.	
[E is the sum of B, Z, if of the *same name*; *difference*, if of a *different* name.]				E 63 26 N.	Sine 9.95154
				Latitude 59 59 N.	Sine 9.93748

The calculations would have been the same for south latitude, which would be 59° 59′ S. The computation of A and B might have been dispensed with, for when the declination is nothing, B is nothing, and A is equal to half the elapsed time (1h) turned into degrees by Table XXI., being, in this example, 15°; in this case, all the logarithms included between the brackets [ ] may be omitted.

In the preceding examples, both altitudes were supposed to be taken at the same place or station; but as that is seldom the case at sea, the necessary correction for any change of place must be made in the following manner:—

Let the bearing of the sun be observed, by the compass, at the instant of the first observation; take the number of points between that bearing and the ship's course, (corrected for lee-way, if she makes any,) with which, if less than eight, or with what it wants of sixteen points, if more than eight, enter the traverse table, and take out the difference of latitude corresponding to the distance run between the observations. *Add* this difference of latitude to the first altitude, if the number of points between the sun's bearing and the ship's course be less than eight; but *subtract* the difference of latitude from the first altitude, if the number of points be more than eight, and that altitude will be reduced to what it would have been if observed at the same place where the second was.* This *corrected* altitude is to be used with the second *observed* altitude in finding the latitude by the above rule. The latitude resulting will be that of the ship at the time of taking the second altitude, and must be reduced to noon by means of the log.

EXAMPLE V.

In a ship, running N. by E. ¾ E. per compass, at the rate of nine knots per hour, at 10h 0m A. M., per watch, the sun's correct central altitude was found to be 13° 18′, bearing S. ¾ E. by compass; and at 1h 40m P. M., per watch, the sun's central altitude was found to be 14° 15′; the latitude by account being 49° 17′ N., and the sun's declination 23° 28′ S. Required the true latitude.

* This is the only correction necessary to make full allowance for the run of the ship; and the inexperienced calculator must take care not to fall into the error of applying a correction to the elapsed time, as is directed in several works of note, particularly in the "*Complete Navigator*," by Dr. Mackay. This will appear evident by supposing, in the above Example V., that a second observer, with a watch, regulated exactly like that used by the first, was at rest at the place of the second observation. Then, at the first observation, *at the same moment of time by both watches*, the first observer would find the sun's altitude 13° 18′, and the second observer 12° 49′. At the second observation, the times and altitudes would be *alike*, so that the elapsed time found by both observers would be the same, and the observations would require no correction, except what arises from reducing the altitude from 13° 18 to 12° 49′, because the second observer is supposed to be at rest, and his observation requires no correction.

Digitized by Google

The correction to the first altitude.

The time elapsed between the observations was 3h 40m, and in that time the ship sailed 33 miles upon the course N. by E. ¾ E., which makes an angle of 13½ points with the sun's bearing at the first observation S. ¾ E., the complement of which to 16 points is 2½ points. Now, in Table I., the course 2½ points, and distance 33m, give 29 miles difference of latitude, which must be subtracted from the first altitude 13° 18′, because the ship sailed above eight points from the sun; therefore the first altitude corrected will be 12° 49′, which must be used in the rest of the work.

Col. 1.	Col. 2.	Col. 3.
El. time [P.M.] 3h 40m, Cosec. 10.33559		
Declination 23° 28′ S. Sec. 10.03749	....	......Cosec. 10.39988
A...............Cosec. 10.37308	Cosine 9.95704	.... Cosine 9.95704
½ sum alts. 13 32 Cosine 9.98777	Cosec. 10.63076	B 26° 05′ S. Cosec. 10.35692
½ diff. alts. 0 43 ...Sine 8.09718	Secant 10.00003	[B less than 90°, named N. or S. like declin.]
C.................Sine 8.45803	Cosine 9.99982	..........Cosine 9.99982
[Z less than 90°, and N. or S. like bearing of zenith.]	Z Sec. 10.58765	Z 75 01 N.
[E is the sum of B, Z, if of the same name; difference, if of a different name.]		E 48 56 N. Sine 9.87734
		Latitude 48 54 N. Sine 9.87716

If the sun had passed the meridian to the north of the observer, Z would have been 75° 01′ S., and E = 101° 06′ S., whose sine 9.99180, added to 9.99982, gives the sine of the latitude 9.99162 corresponding to 78° 47′ S.

EXAMPLE VI.

Sailing N. E. ½ E. by compass, at the rate of nine knots an hour, at 0h 31m 40s P. M., per watch, the altitude of the sun's lower limb was 28° 20′ above the horizon of the sea, the eye being elevated twenty feet above the surface of the water, and the sun's bearing by compass S. by W.; and at 2h 58m 20s P. M., by watch, the altitude of the sun's lower limb was 16° 41′ above the horizon, the eye being elevated as before, the latitude by account, at the time of the last observation, 48° 0′ N., and the declination 13° 17′ S. Required the true latitude at taking the last observation.

The correction of these altitudes for semidiameter, parallax, and dip, was twelve miles, (additive,) which makes them 28° 32′, and 16° 53′. The refraction corresponding to the first was 2 miles, and for the second 3 miles; and, by subtracting these quantities, we have the true central altitudes, 28° 30′, and 16° 50′. Now, the elapsed time between the observations was 2h 26m 40s, during which the ship sailed twenty-two miles (at nine miles per hour) in the direction of N. E. ½ E. per compass, the bearing of the sun at the first observation S. by W. being 12½ points distant from the ship's course; and as 12½ points want 3½ of 16 points, we must enter Table I., and find the course 3½ points, and distance 22, corresponding to which in the latitude column is 17 miles, which, being subtracted from the first altitude 28° 30′, leaves the corrected first altitude 28° 13′; with this, and the second altitude 16° 50′, the latitude is found in the following manner:—

Col. 1.	Col. 2.	Col. 3.
El. time [P.M.] 2h 26m 40s, Cosec. 10.50232		
Declination 13° 17′ S. Secant 10.01178	....	..Cosec. 10.63871
A.................Cosec. 10.51410	Cosine 9.97861	............Cosine 9.97861
½ sum alts. 22 31½ . Cosine 9.96553	Cosec. 10.41670	B 13° 58′ S. Cosec. 10.61732
½ diff. alts. 5 41½ ....Sine 8.99640	Secant 10.00215	[B less than 90°, named N. or S. like declin.]
C...................Sine 9.47603	Cosine 9.97962	..............Cosine 9.97962
[Z less than 90°, and N. or S. like bearing of zenith.]	Z Sec. 10.37708	Z 65 11 N.
[E is the sum of B, Z, if of the same name; difference, if of a different name.]		E 51 13 N. Sine 9.89183
		Latitude 48 03 N. Sine 9.87145

Digitized by Google

If the sun had passed the meridian to the north of the observer, Z would have been 65° 11′ S., and E = 79° 09′ S., whose sine 9.99217, added to cosine of C 9.97962, gives the sine of the latitude 9.97179, corresponding to 69° 34′ S.

EXAMPLE VII.

[Same as Dr. Brinkley's, in the Nautical Almanac for 1800.]

The latitude by account 6° 30′ N., sun's declination 5° 30′ N., the sun's correct central altitudes 35° 21′, and 70° 01′, elapsed time between the observations $2^h\ 20^m$; required the latitude, the sun passing the meridian south of the observer.

El. time [P.M.] $2^h 20^m$, Cosec. 10.52186		
Declination 5° 30′ N. Sec. 10.00200	....	Cosec. 11.01843
A .... Cosec. 10.52386	Cosine 9.97962	.... Cosine 9.97962
½ sum alts. 52 41 Cosine 9.78263	Cosec. 10.09947	B 5° 46′ N.... Cosec. 10.99805
½ diff. alts. 17 20 Sine 9.47411	Secant 10.02018	[B less than 90°, named N. or S. like declin.]
C .... Sine 9.78060	Cosine 9.90170	.... Cosine 9.90170
[Z less than 90°, and N. or S. like bearing of zenith.]	Z Sec. 10.00097	Z 3 50 N.
[E is the sum of B, Z, if of the same name, *difference*, if of a *different* name.]		E 9 36 N..... Sine 9.22211
		Lat. 7 38 N..... Sine 9.12381

If the sun had passed to the meridian *north* of the observer, Z would have been 3° 50′ S., and E = 1° 56′ N., whose sine 8.52810, added to the cosine of C 9.90170, is 8.42980, which is the sine of the other latitude 1° 32′ N., so that in this example both latitudes are *north*.

SECOND METHOD

Of finding the latitude by double altitudes of the sun, when the variation of declination is neglected.

This method of finding the latitude depends on a set of tables (marked XXIII., in this collection,) first prepared by Mr. Douwes, containing three logarithms, titled *half elapsed time*, *middle time*, and *log. rising*. The two former are arranged together as far as six hours; the latter is placed at the end of the table, and is extended, in the present edition, as far as twelve hours. The table with the proper title must be entered at the top with the hour, at the side with the minute, and in the column marked at the top with the seconds; the corresponding number will be the sought logarithm, to which must be prefixed the index of the log. under 0″ in the same horizontal line. Thus, to the time $3^h\ 52^m\ 10^s$ correspond the log. half elapsed time 0.07138, log. middle time 5.22965, and log. rising 4.67274. In general it will be sufficiently exact to take these logarithms to the nearest 10 seconds, particularly when the sun's zenith distance is great; but if the log. to the nearest second is required, it may be found by taking the difference of the tabular logarithms corresponding to the next greater and next less time, and saying, As 10^s is to that difference, so are the odd seconds of time to the correction of the first tabular logarithm, additive if increasing, subtractive if decreasing. Thus, if the log. half elapsed time corresponding to $3^h\ 52^m\ 18^s$ were required, the logs. corresponding to $3^h\ 52^m\ 10^s$ and $3^h\ 52^m\ 20^s$ are 0.07138 and 0.07119, whose difference is 19; then $10^s : 19 :: 8^s : 15$; this, subtracted from 0.07138, leaves 0.07123, the sought logarithm. By inverting the process, we may find the nearest second corresponding to any given logarithm. We shall now give the rule for calculating the latitude, adapted to double altitudes of the sun.

RULE.

To the log. secant of the latitude by account (Table XXVII.) add the log. secant of the sun's declination, (Table XXVII.,) rejecting 10 in each index; the sum is to be called the log. ratio.

Digitized by Google

From the natural sine of the greatest altitude (Table XXIV.) subtract the natural sine of the least altitude, (Table XXIV.;) find the logarithm * of their difference, (in Table XXVI.,) and place it under the log. ratio.

Subtract the time of taking the first observation from the time of taking the second, having previously increased the latter by twelve hours when the observations are on different sides of noon by the watch; take half the remainder, which call half the elapsed time.

With half the elapsed time enter Table XXIII., and from the column of half elapsed time take out the logarithm answering thereto, and write it under the log. ratio.

Add these three logarithms together, and with their sum enter Table XXIII. in the column of middle time, where, having found the logarithm nearest thereto, take out the time corresponding, and put it under half the elapsed time. The difference between these times will be the time from noon when the greater altitude was taken.

With this time enter Table XXIII., and, from the column of log. rising, take out the logarithm corresponding, from which logarithm subtract the log. ratio; the remainder will be the logarithm of a natural number, which, being found in Table XXVI.,† and added to the natural sine of the greater altitude, will give the natural cosine of the sun's meridian zenith distance, which may be found in Table XXIV. Hence the latitude may be obtained by the rules of pages 166, 167.

NOTES.

1. If this computed latitude should differ considerably from the latitude by account, it will be proper to repeat the operation, using the latitude last found instead of the latitude by account, till the result gives a latitude nearly agreeing with the latitude used in the computation.

2. This method is best suited to situations where the sun's meridian zenith distance is not much less than half the latitude; for in latitudes where the sun approaches near to the zenith, the observations must be taken much nearer to noon; and the preceding rule, instead of approximating, will in some cases give the results of successive operations wider and wider from the truth. To remedy this difficulty, a set of tables was published, by Dr. Brinkley, at the end of the Nautical Almanac for 1799; but the great variety of cases incident to his method, will hinder it from being generally used. Instead of Dr. Brinkley's method, we may generally use the method of arithmetical computation, called *Double Position*, which will frequently give, in a more simple manner, the required latitude, as will be shown in Example X.; and, in *general*, it may be observed, that where Douwes's rule does not approximate, the object is most commonly so situated as not to furnish the necessary observations to obtain a correct latitude, whatever method of computation might be used.

3. The operation is the same whether the sun has north or south declination; and also whether the ship is in north or south latitude. When the sun has no declination, the log secant of the latitude (rejecting 10 in the index) will be the log. ratio; and when the latitude by account is nothing, the secant of the declination (rejecting 10 in the index) will be the log. ratio. This rule, as well as the former, is founded on the supposition that the declination is taken for the middle time between the observations, and that it does not vary during the elapsed time, which, however, rarely happens, and a correction ought to be applied to the latitude on this account. But this correction is generally small; and if it is large, the *third* method must be used; and when the declinations differ very much from each other, we must use the *fourth* method.

* The index of this logarithm being, as usual, one less than the number of figures contained in the difference of these natural sines; observing, also, that the altitudes to be used are the correct central altitudes; that is, the observed altitudes corrected for dip, semidiameter, parallax, and refraction.

† Taking, as usual, a number of figures equal to the index of that logarithm increased by unity

Digitized by Google

EXAMPLE VIII.

[Same as EXAMPLE I., preceding.]

Being at sea, in latitude 46° 30′ N. by account, when the sun's declination was 11° 17′ N. at $10^h\ 2^m$ in the forenoon, the sun's correct central altitude was 46° 55′ and at $11^h\ 27^m$ in the forenoon, his correct central altitude was 54° 9′; required the true latitude, and true time of the day when the greater altitude was taken.

	Times.	*Alt.*	*Nat. Si.*	
2 obser.	$11^h\ 27^m\ 00^s$	54° 9′	81055	Lat. by acc.....46° 30′.....Sec. 0.16219
1 obser.	10 2 0	46 55	73036	Dec...........11 17.....Sec. 0.00848
				Log. ratio..................... 0.17067
Elap. time	1 25 0	Diff. Nat. Sines,	8019	Log. diff. Nat. Sines........... 3.90412
½ elap. time	0 42 30			Log. ½ elap. time............... 0.73429
	Middle time......	$1^h\ 15^m\ 10^s$		.... 4.80908
	½ elap. time......	42 30		
	2 obs. from noon	0 32 40		Its log. rising................. 3.00608
				Log. ratio sub.................. 0.17067

Nat. numb. .... 685....corresponding to log. 2.83541
Nat. sine greatest alt. 81055

Sum is nat. cosine ☉'s zen. dist. 81740...equal to 35° 10′ N.
☉'s declination................................ 11 17 N.

Lat. in .... 46 27 N.

The latitude 46° 27′ (differing only 3′ from the latitude by account) may be assumed as the true latitude.

By means of the time of the second observation from noon above found $32^m\ 40^s$, the error of the watch may be found; for, in the present example, by subtracting $32^m\ 40^s$ from 12^h, we have the time of the second observation $11^h\ 27^m\ 20^s$; but the time of the watch was $11^h\ 27^m\ 0^s$; therefore the watch was twenty seconds too slow; a small difference would be found in these numbers, if we were to proportion the logarithms of Table XXIII. to seconds. In the same manner, the error of the watch may be found in the following examples.*

EXAMPLE IX.

[Same as EXAMPLE V., before given.]

In this example the latitude by account is 49° 17′ N.; the sun's declination 23° 28′ S. the first altitude corrected, as before, 12° 49′; the second altitude 14° 15′. Required the true latitude.

		Alt.	*Nat. Si.*	
2 obser.	$13^h\ 40^m\ 0^s$	14° 15′	24615	Lat. by acc.....49° 17′.....Sec. 0.18554
				Declination....23 28.....Sec. 0.03749
1 obser.	10 0 0	12 49	22183	Log. ratio..................... 0.22303
Elap. time	3 40 0	Diff. nat. si.	2432	Its log........................ 3.38596
½ elap. time	1 50 0			Its log. 0.33559
Mid. time	0 10 10	Time corresponding to		.... 3.94458
2 obser. from noon,	1 39 50	Its log. in col. of rising is		.... 3.97028
		Log. ratio		.... 0.22303

5588 Nat. number of...........Log. 3.74725
Nat. sine greatest alt.............. 24615

Nat. cosine ☉'s mer. zen. dist. ..... 30203 = 72° 25′ N.
Declination............................ 23 28 S.

Latitude................................ 48 57 N.

* When the middle time is greater than half the elapsed time, both observations are on the same side of the meridian; otherwise, on different sides; whence it is easy to determine whether the greater altitude be observed before or after noon

Digitized by Google

But as the latitude by computation differs considerably from that by account, the work must be repeated.

		Lat. last found... 48° 57′ ...Sec.	0.18262
		Declination...... 23 28 ...Sec.	0.03749
		Log. ratio	0.22011
		Diff. N sine 2432........Its log.	3.38596
½ elapsed time............ ..	$1^h\ 50^m\ 0^s$	......................Its log.	0.33559
Middle time.............. ..	0 10 0	Its log.	3.94166
Time from noon	1 40 0	Its log. in col. of rising	3.97170
		Log. ratio....................	0.22011
	5644	Nat. number of ....Log.	3.75159
Nat. sine greatest altitude	24615		
	30259	Nat. cos. mer. zen. distance ...	72° 23′ N.
		Declination	23 28 S.
		True latitude	48 55 N.

This latitude (differing only two miles from that which is used in the computation) may be depended upon as the true latitude of the ship, at the time of the second observation. If the first altitude had not been corrected, the computed latitude would have been found = 48° 40′ N.

EXAMPLE X.

[Same as EXAMPLE VII., before given.]

The latitude by account 6° 30′ N., sun's declination 5° 30′ N., the sun's correct central altitudes 35° 21′ and 70° 01′, elapsed time $2^h\ 20^m$, are given to find the true latitude.

Making the calculations with the latitude by account 6° 30′, the computed latitude by the first operation will be 8° 16′. Repeating the operation with the latitude 8° 16′, the second operation will give 7° 10′.* This must be used for a third operation; and by repeating the calculation accurately to seconds, it will require more than a dozen operations to obtain the true latitude 7° 38′, which was found, by the first method, by a single operation. Dr. Brinkley made the latitude 7° 30′, differing 8′ from a strict calculation by spherical trigonometry. The detail of this calculation is not here given, but is left to exercise the learner. The object of the present example is to show how the number of operations might be decreased by the arithmetical method of *double position* before mentioned.

Lats.		Errors.		Produc's.
6° 30′	X	106	=	876° 16′
8 16		66	=	429 00
		172)		1305 16 (7° 35′.

Take the *error* or difference between the first assumed latitude 6° 30′, and the first computed latitude 8° 16′, equal to 106′; also the *error* or difference between the second assumed latitude 8° 16′, and second computed latitude 7° 10′, which is 66′. Multiply them *crosswise*, as in the adjoined scheme, according to the usual rule of *double position*;† dividing the sum of the products 1305° 16′, by the sum of the errors 172, gives the corrected latitude 7° 35′ N. The *sum* of the products is taken in this case, because one of the assumed latitudes was *greater*, and the other *less*, than its corresponding computed latitude. If both computed latitudes had been *greater*, or both *less*, than the corresponding assumed latitudes, the *differences* of the errors and of the products ought to have been taken. It will rarely happen that more than one process of this kind will be required to give a correct result. In the present instance, however, it will be necessary; for, by repeating the operation with the assumed latitude 7° 35′, the resulting computed latitude is 7° 41½, and the third error 6½′. Repeating anew the computation, with this and the second latitude 8° 16′, and second error 66′, the resulting latitude is 7° 38′, the same as was found by the direct computation by the first method, and as accurately as could be obtained by repeating the operations about fourteen times by the second method.

In general, when such a large number of operations are required to produce a correct result, it is a sure proof that the situation of the object is not well adapted to

* Slight differences will be found in these calculations, by using logarithms to seven places of figures, and making the calculation accurately to seconds.

† If the degrees of both latitudes are alike, the minutes only may be retained in these multiplications.

Digitized by Google

obtain an accurate latitude; and it would be lost labor, and lead to great mistakes, to attempt it. Thus, in the present example, if the greatest altitude had been decreased only 12′ 42″, making it 69° 48′ 18″, leaving unaltered the other altitude 35° 21′, and the interval 2^h 20^m, the latitude of the place of observation would be 0, (or under the equator,) as is easily proved by computing the altitudes of the sun for the times 1^h 17^m $50^s.8$, and 3^h 37^m $50^s.8$, under the equator, when the declination is 5° 30′ N., by the rules hereafter given. Hence it appears that a change of 12′ 42″ in the greatest altitude, would alter the computed latitude from 7° 38′ to 0°, which makes an error of one degree of latitude for an error of 1⅔ miles in that altitude; and as errors in the altitudes of this magnitude are easily committed at sea, even by very good observers, it shows very clearly the defect of the method of double altitudes when the sun approaches near to the zenith. This does not arise from any defect of the method of computation, but is an inherent defect of the method itself, which no process of spherics can remedy; and there is no other resource left, in such cases, than to make use of another object to determine the latitude.

THIRD METHOD

Of finding the latitude by two altitudes of any heavenly body, noticing the change in the declination during the time between the two observations.

To determine the latitude accurately, reducing the change in the declination of the object, we have computed Table XLVI., by means of which the correction of either one of the observed altitudes can be computed for the change of declination of the observed object during the elapsed time between the observations, and thus the problems of double altitudes of the sun, moon, planet, or fixed star, can be reduced to the case of the declination, being invariably the same as at the time of the observation of the altitudes which is not corrected, and then the problem comes under the *first* (or second) method of solution, which is much more simple and free from cases than the general solution by the *fourth* method. This process of correcting the altitude is somewhat similar to that before taught, for making allowance for the run of a ship during the time elapsed between the observations; and the same altitude, which is corrected for the run of the ship, can also be corrected for the change of declination. This method of correcting one of the altitudes is particularly applicable to the case where *both* observations are made on the *same* heavenly body, and the declination does not vary but few minutes, or, in extreme cases, more than one or two degrees; but the same process may be used when two *different* objects are observed, provided their declinations are nearly equal, or do not differ more than one or two degrees.

As either one of the altitudes may be corrected, the problem admits of two different ways of solution. For the sake of precision, the altitude which is selected to be corrected, will be called the *first altitude*; and the corresponding declination, the *first declination*; the other altitude, which is not corrected, will be called the *second altitude*, and the corresponding declination, the *second declination*; these terms, *first* and *second*, having no reference to the order in which these observations are taken, since the altitude here defined as the *first altitude*, may be actually observed either *before* or *after* the other observation.

The proposed table gives for various declinations, altitudes, and latitudes, the change of the *first altitude*, corresponding to a variation of 100″ in the *first declination*. Thus, with the latitude 50° N., the sun's altitude 30°, and the declination 14° N., the table gives 77″ for the variation of that altitude arising from a change of 100″ in the declination. If the actual change of declination is greater or less than 100″, the tabular number 77″ must be increased or decreased in the same proportion. Thus, if the change of declination be 200″, the change of altitude will be $200'' \times \frac{77}{100} = 154''$. If the change of declination be 60″, the change of altitude will be $60'' \times \frac{77}{100} = 46''$. The correction of this *first altitude* having been found, it is to be applied to the first altitude, corrected as usual, for dip, refraction, semidiameter, and parallax, and the *corrected* first altitude will be obtained, such as it would have been, if the declination at the time of observing that altitude had been equal to the *second declination*. With this corrected first altitude, the second altitude and second declination without correction, and the observed elapsed time, or hour angle, the computation of the latitude may be made by the *First Method*, explained in page 180, or by the *Second Method*, in page 185.

This table is calculated for every 2° of declination, from 0° to 26°. If the change of declination is not very great during the elapsed time, it will in general be

Digitized by Google

sufficiently exact to enter the table with the nearest declination, and take proportional parts for the degrees of altitude and latitude. The latitude by account is to be used in finding the numbers from this table, it being sufficiently accurate, since an error of 1° of latitude rarely produces more than 2″ change in the numbers of the table. Suppose, now, that the tabular number is required, when the latitude is 37° N., the *first* altitude 28°, the first declination 6° 25′ S. In this case, using the declination 6°, and the altitude 20°, the tabular numbers corresponding to the latitudes 30° S. and 40° S. are, respectively, 57″ and 73″, whose difference 16″ corresponds to a change of 10° of latitude, and by proportion, the change corresponding to 7° of latitude is $16'' \times \frac{7}{10} = 11''.2$; this being added to 57″, gives the correction corresponding to the altitude 20°, and the latitude 37° S. equal to 68″.2. Repeating now the same operation with the altitude 30°, the two tabular numbers are 64″ and 81″, whose difference 17″, being multiplied by $\frac{7}{10}$, gives 11″.9 to be added to 64″ to get 75″.9, the correction corresponding to the altitude 30° and the latitude 37° S. Hence it appears that by changing the altitude from 20° to 30°, the correction changes from 68″.2 to 75″.9, increasing 7″.7, by an increase of 10° in the altitude; the corresponding increase for a change of 8° in the altitude is equal to $7''.7 \times \frac{8}{10} = 6''.2$, nearly. This being added to 68″.2, gives 74″.4, for the tabular number corresponding to the declination 6°, the altitude 28°, and the latitude 37° S. If the same calculation be repeated, using the declination 8°, the tabular number will be 76″.2, instead of 74″.4, increasing only 1″.8 for an increase of 2° = 120′ in the declination, and the corresponding correction for the 25′ of the first declination is $1''.8 \times \frac{25}{120} = 0''.4$, nearly. This being added to 74″4, gives the correct tabular number 74″.8, or 75″, nearly, corresponding to the proposed latitude, 37° S., altitude 28°, or declination 6° 25′ S. The correction for the minutes of declination is in this case small, and in general it will be so; and when the change of declination during the elapsed time is only a few minutes, it will be sufficiently exact to take out, according to the above directions, the numbers corresponding to the nearest declination in the table. As there is nothing peculiar in this method of finding the corrections for the intermediate degrees of altitude and latitude. (several tables in the work having been arranged upon a somewhat similar plan,) it will not be necessary to go into any further detail relative to the manner of finding the number from the table corresponding to any proposed declination, altitude, or latitude. The use of these numbers in finding the correction of the first altitude, is, for the sake of easy reference, drawn up in the following rules.

RULE.

1. *If the two declinations are of the same name, take their difference; if they are of different names, take their sum; and this difference, or sum, will be the change of declination corresponding to the two observations, or two objects.*

2. *Find in Table XLVI. the number corresponding to the first declination, the first altitude, and the latitude by account. Multiply this by the change of declination, in seconds, between the two observations; the product, rejecting the two right-hand figures, will be the number of seconds to be applied to the first altitude, with the same sign as in the table,* if, at the second observation, the object is nearer to the elevated pole than at the first observation; but with a different sign from the table, if, at the second observation, the object is farther from the elevated pole than at the first observation.*

Thus, in the above example, where the tabular correction is 75″, if the second altitude is 48° and the second declination 6° 15′ S., which is 10′ or 600″ less than the *first* declination 6° 25″ S., the product of 600″ by 75 (rejecting the two right-hand figures) is 450″ = 7′ 30″, being the correction to be added to the first altitude 28°, making it 28° 7′ 30″, because the second declination is nearest to the elevated pole. If the second declination be 6° 35′ S., instead of 6° 15′ S., the correction 7′ 30″ will be subtractive, making it 27° 52′ 30″.

It may be observed, that the method of correcting one of the altitudes *does not alter the horary angles in any way whatever*, and the regulation of the watch used in the observation is calculated in exactly the same manner as if the correction had not been made, and whichever altitude is corrected, the result will be very nearly the same; a

* The signs in the table are positive except in a few places between the tropics. In all cases without the tropics, when the distance from the elevated pole *decreases*, the altitude is to be *increased*, and when the polar distance *increases*, the altitude is to be *decreased*. The contrary takes place in those latitudes between the tropics where the tabular numbers have the sign — prefixed. It may also be observed, that the tabular number, corresponding to any possible situation of the object, cannot exceed 100″; it was, however, found convenient to insert a few numbers exceeding 100″, for the purpose of finding more accurately the proportional parts for the intermediate degrees of altitude or latitude corresponding to possible cases.

Digitized by Google

difference of a few seconds will sometimes be found, owing to the small quantities neglected.

To illustrate this, the following examp es are given :—

EXAMPLE XI.

The sun's correct cer tral altitude was 32° 25′, his declination 17° N. Eight hours afterwards, by a watch, his correct central altitude was 30° 8′, and declination 16° 55′ N. Required the latitude, supposing the latitude by account to be 53° 20′ N.

The tabular correction corresponding to the first altitude 32° 25′, declination 17° N., and latitude by account 53° 20′ N., is 80″. Multiplying this by the difference of the declination 17° — 16° 55′ = 5′ = 300″, the product (rejecting the two right-hand figures) is 240″.00 = 4′, the correction of altitude. This is to be subtracted from 32° 25′, because the sun recedes from the elevated pole, while the declination changes from 17° N. to 16° 55″ N.; therefore the corrected *first* altitude is 32° 21″. Using this with the second altitude 30° 8′, the second declination 16° 55′, and the elapsed time 8 hours, the calculation may be thus made by the *first method*, as follows:—

Col. 1.		Col. 2.		Col. 3.	
El. time 8h [P. M.] Cosec.	10.06247				
Declination 16° 55′ N. Sec.	10.01921			..........................Cosec.	10.53614
A................Cosec.	10.08168	Cosine	9.74812	.... Cosine	9.74812
½ sum alts. 31 14½ Cosine	9.93196	Cosec.	10.28512	B 31° 18′ N. Cosec.	10.28426
½ diff. alts. 1 6½ Sine	8.28650	Sec.	10.00008	[B less than 90°, named N. or S. like the declin.]	
C......... 1 9 Sine	8.30014	Cosine	9.99991	..........Cosine	9.99991
[Z less than 90°, named N. or S. like the bearing of the zenith.]		Z sec.	10.03323	Z 22 8 N.	
[E is the *sum* of B, Z, if of the *same* name; *difference*, if of a *different* name.]				E 53 26 N. Sine	9.90480
				Latitude 53 25 N. Sine	9.90471

As it is entirely arbitrary which altitude is considered as the *first*, or the one to be corrected, it may not be amiss to repeat the operation, considering 30° 8′ as the *first* altitude, and 16° 55′ as the *first* declination. The tabular number corresponding to these quantities, and the latitude by account, is 79″, which, being multiplied by the change of declination 300″, (rejecting the two right-hand figures,) gives 237″ = 3′ 57″, or 4′ nearly. This is to be added to 30° 8′ to get the corrected *first* altitude 30° 12′, because the sun *approaches* the elevated pole, while his declination changes from 16° 55′ to 17°. Assuming, therefore, the corrected *first* altitude as 30° 12′, the *second* altitude 32° 25′, the *second* declination corresponding thereto 17° N., and the elapsed time, as before, 8 hours, the calculation may be then made as follows:—

Col. 1.		Col. 2.		Col. 3	
El. time 8h [P. M.] Cosec.	10.06247				
Declination 17° N. Sec.	10.01940			..........................Cosec.	10.53406
A................Cosec.	10.08187	Cosine	9.74820	..........Cosine	9.74850
½ sum alts. 31° 18½ Cosine	9.93165	Cosec.	10.28429	B 31° 27′ N. Cosec.	10.28256
½ diff. alts. 1 6½ Sine	8.28650	Sec.	10.00008	[B less than 90°, named N. or S. like the declin.]	
C......... 1 9 Sine	8.30002	Cosine	9.99991	..........Cosine	9.99991
[Z less than 90°, named N. or S. like the bearing of the zenith.]		Z Sec.	10.03278	Z 21 59 N.	
[E is the *sum* of B, Z, if of the *same* name; *difference*, if of a *different* name.]				E 53 26 N. Sine	9.90480
				Latitude 53 25 N. Sine	9.90471

So that the latitude is exactly the same by both methods.

If the middle time between the two observations be required, it would be obtained by adding the log. tangent of C 8.30263, to the log. secant of E 10.22493; the sum, rejecting 10 in the index, is 8.52756, which, being sought for in the log. tangents, correspond in the Col. P. M. to 0h 15m 26s, whose half 0h 7m 43s is the middle time between the two observations. Taking the sum and difference of this and half

Digitized by Google

the elapsed time, 4^h, gives the times from noon when the observations were made, $4^h\ 7^m\ 43^s$ and $3^h\ 52^m\ 17^s$, the one being before noon, the other afternoon. The same result is obtained whichever altitude is corrected.

EXAMPLE XII.

Suppose we have, at the same moment of time, the moon's correct central altitude 55° 20′, the moon's declination 0° 36′ N.; the sun's correct central altitude 37° 40′, his declination 0° 17′ S; the *hour angle*, or difference of the right ascensions of the sun and moon, as given by the Nautical Almanac, 5 hours; required the true latitude, the latitude by account being 23° 20′ N.

The tabular correction corresponding to the latitude by account 23° 20′ N., the sun's altitude 37° 40′, (considered as the *first* altitude,) and the declination 0° 17′ S., is 50″, and the change of the two declinations from 0° 17′ S. to 0° 36′ N. is (53′ =) 3180″ this being multiplied by 50, and the two right-hand figures rejected, gives the correction of altitude 1590″ = 26′ 30″; this is to be added to the altitude 37° 40′, because the change of the sun's declination from 0° 17′ S. to 0° 36′ N., approaches the sun to the elevated pole; therefore the sun's corrected altitude is 38° 6′ 30″, or simply 38° 6′. Using this with the moon's altitude 55° 20′, the moon's declination 0° 36′ N., and the hour angle 5 hours, the latitude may be found by the *first method*, in the following manner:—

Col. 1.		Col. 2.		Col. 3.	
Elapsed time 5^h, P.M. Cosec.	10.21555				
Declination 0° 36′ N. Sec.	10.00002	....		........Cosec.	11.97998
A.................Cosec.	10.21557	Cosine	9.89947	.........Cosine	9.89947
½ sum alts. 46 43..Cosine	9.83608	Cosec.	10.13789	B 0° 45′½ N. Cosec.	11.87945
½ diff. alts. 8 37 ...Sine	9.17558	Secant	10.00493	[B less than 90°, named N. or S. like the declin.]	
C..................Sine	9.22723	Cosine	9.99372	.........Cosine	9.99372
[Z less than 90°, named N. or S. like the bearing of the zenith.]		Z Sec.	10.03601	Z 23 0½ N.	
E is the *sum* of B, Z, if of the *same* name; *difference* if of a *different* name.]				E 23 46 N. Sine	9.60532
				Latitude 23 24 N. Sine	9.59904

If the moon's altitude, 55° 20′, be considered as the *first* altitude, and corrected, the tabular number corresponding to this altitude, the moon's declination 0° 36′ N., and the latitude by account 23° 20′ N. will be 70″. Multiplying this by the change of declination 3180″, and neglecting the two right-hand figures, gives the correction of altitude 2226″ = 37′ 6″, or simply 37′, which is to be subtracted from the moon's altitude 55° 20′ to obtain the corrected altitude 54° 43′, because the change from 0° 36′ N. to 0° 17′ S. makes the moon recede from the elevated pole. Using the corrected altitude 54° 43′, the sun's declination 0° 17′ S., and the sun's altitude 37° 40′, with the hour angle 5^h, the latitude may be found by the *first method*, in the following manner:—

Col. 1.		Col. 2.		Col. 3.	
Elapsed time 5^h, P.M. Cosec.	10.21555				
Declination 0° 17′ S. Sec.	10.00001	....		........Cosec.	12.30583
A.................Cosec.	10.21556	Cosine	9.89947	........Cosine	9.89947
½ sum alts. 46 11½* Cosine	9.84026	Cosec.	10.14167	B 0° 21′½ S. Cosec.	12.20530
½ diff. alts. 8 31½ ...Sine	9.17097	Secant	10.00482	[B less than 90°, named N. or S. like the declin.]	
C..................Sine	9.22679	Cosine	9.99374	........Cosine	9.99374
[Z less than 90°, named N. or S. like the bearing of the zenith.]		Z Sec.	10.03970	Z 24 7½ N.	
E is the *sum* of B, Z, if of the *same* name; *difference* if of a *different* name.]				E 23 46 N. Sine	9.60532
				Latitude 23 24 N. Sine	9.59906

Which agrees with the preceding calculation.

---

* In taking the half-sum and half-difference of the altitudes, it will be convenient to prove the accuracy of the calculation by adding this half-sum to the half-difference, for the *sum* will be the greater altitude. The difference of the same numbers will be the least altitude. Thus, in the present example, 46° 11′½ + 8° 31′½ = 54° 43′, the greater altitude, and 46° 11′½ − 8° 31′½ = 37° 40′, the least altitude.

Digitized by Google

EXAMPLES FOR EXERCISE IN THIS THIRD METHOD.

1. The sun's correct central altitude was 41° 33′ 12″, his declination 14° N. After an interval of $1^h\ 30^m$, his correct central altitude was 50° 1′ 12″, and declination 13° 58′ 38″; latitude by account 52° 5′ N. Required the true latitude.

The tabular number corresponding to the altitude 41° 33′ 12″ is 87″, and this being taken for the first altitude, is, when corrected, 41° 32′ 0″; the second altitude is 50° 1′ 12″, the elapsed time $1^h\ 30^m$, and the declination 13° 58′ 38″ N. These make the latitude 52° 5′ N.

Or, by taking 50° 1′ 12″ for the first altitude, and using the corresponding declination. the tabular number is 95″, the corrected *first* altitude becomes 50° 2′ 30″; using this, with the *second* altitude 41° 33′ 12″, the declination 14° N., and the elapsed time $1^h\ 30^m$, we find that the latitude becomes, as before, 52° 5′ N.

2. Given the correct central altitude of the moon 53° 43′, her declination 14° 16′ N. After an interval, in which the hour angle was $1^h\ 44^m\ 15^s$, her correct central altitude was 42° 29′, and declination 13° 52′ N.; the latitude by account 48° 54′ N. Required the true latitude.

With the first altitude and first declination the tabular number is 98″, and the corrected first altitude 53° 19′ 28″, the second altitude 42° 29′; with which the declination 13° 52′ N., and the corrected elapsed time or hour angle $1^h\ 44^m\ 15^s$, we find that the latitude is 48° 55′ N.

Or, by taking 42° 29′ for the first altitude, and 13° 52′ N. for the first declination, the tabular correction will be 83″, and the corrected *first* altitude 42° 49′; using this, and the *second* altitude 53° 43′, the corresponding second declination 14° 16′ N., and the hour angle $1^h\ 44^m\ 15^s$, we find the latitude to be 48° 54′ N., nearly; agreeing with the former calculation.

3. Given the correct central altitude of the moon, 55° 38′, her declination 0° 20′ S. After an interval in which the hour angle was $5^h\ 30^m\ 49^s$, her correct central altitude was 29° 57′, and her declination 1° 10′ N.; the latitude by account 23° 25′ S. Required the true latitude.

With the *first* altitude 55° 38′, and the *first* declination 0° 20′ S., the tabular correction is 71″, and the *first* corrected altitude 54° 34′ 6″. Using this with the *second* altitude 29° 57′, the second declination 1° 10′ N., and the hour angle $5^h\ 30^m\ 49^s$, the true altitude will be found 23° 23′ S.

Or, by taking 29° 57′ for the *first* altitude, and 1° 10′ N. for the *first* declination, the tabular correction will be 45″, and the first corrected altitude 30° 37′. Using this with the *second* altitude 55° 38′, the second declination 0° 20′ S., and the hour angle $5^h\ 30^m\ 49^s$, the true latitude will be found to be 23° 24′ S., nearly agreeing with the preceding calculations.

In making the calculations of these three examples, the seconds were noticed, which is always best to be done, particularly when the altitudes are nearly equal; some difference might be found in the above results if the nearest minutes only were taken. Thus, Example XI., calculating to the nearest minute, gives the latitude 53° 28′. If the calculation be made as in page 191, it becomes 53° 25′, differing 3′. This difference would be avoided by taking the angles to seconds, and in some extreme cases it would require the use of 6 or 7 places of decimals.

FOURTH METHOD.

To find the latitude by double altitudes of the same or different objects, the declinations being different.

This method, like the *first*, requires only the use of Table XXVII.; and the words *sine*, *cosine*, &c., are written for *log. sine*, *log. cosine*, &c. The logarithms are arranged in these columns as in the first method, according to the following formula, which ought to be written down before the calculation is commenced; this will simplify the operation, and may prevent mistakes. In this formula it is said that C is of the same *affection* as B; the meaning of which is, that if B is *less* than 90°, C also is *less* than 90°; and if B is *greater* than 90°, C also is *greater* than 90°. Likewise A is of the same affection as the hour angle H, meaning that if the hour angle is *less* than 6 hours or 90°, A will be *less* than 90°; and if the hour angle *exceed* 6 hours, the angle A will *exceed* 90°.

Digitized by Google

FORMULA.

Col. 1.	Col. 2.	Col. 3.
Hour angle H [P.M.]..Sec.	....	..........Tan
Decli. d [at gr. alt.] Tan.	........................Sine	
A [diff. name from d.] Tan.	A [same affection as H] Cosec.	.........Cosine
D. Dec. [at least alt.]		
B............	.... Cosine	.........Cosec.
C............ Cosec.	C [same affection as B] Cosine	F Cotan.
		Z [F less than 90°, diff. name from B.]
	G.....................Sine	G
Least altitude.... Sec	.... Cotan.	..............Sine
Greatest altitude..	I Tan.	[I less than 90°] Sec [I named as G.]
Sum, 3 last num.	Dec D [at least alt.]	
½ Sum........... Cosine	K	.... Sine
½ S—g. alt.=Rem. Sine	Latitude	Sine
Sum of 4 logs. 2)		
½ Z............. Sine		

[Z named N. or S., like the bearing of the zenith.]

In some late works on navigation, no notice is taken of the cases where the hour angle exceeds 90°, or the distance of the objects exceeds 90°, and on that account the rules appear *less* subject to different cases than the following rule, which embraces all possible cases, and the apparent simplicity of the rules referred to, arises from their *imperfections* and *incompleteness*.

RULE.

1. Find the hour angle H,* and take out the corresponding secant, which put in Col. 1, and its tangent in Col. 3.

2. Take the declination d, corresponding to the *greatest* altitude, place its tangent in Col. 1, its sine in Col. 2.

3. The sum of the two logarithms in Col. 1 (rejecting 10 in the index) is the tangent of the angle A, which is *less* than 90° if the hour angle is *less* than 6 hours, (or 90°,) but *greater* than 90° if the hour angle is greater than 6 hours. This angle is to be marked *north* or *south*, with a different name from the declination d, at the greatest altitude. The cosecant of A is to be placed in Col. 2, its cosine in Col. 3.

4. Place the declination D, corresponding to the *least* altitude, below the angle A, and if they are of the† *same* name, take their *sum*, but if of *different* names, take their *difference*, and call this sum,‡ or difference, the angle B, making it *north* or *south*, like the greatest of the two quantities A, D. The cosine of B is to be placed in Col. 2, its cosecant in Col. 3.

5. The sum of the three logarithms in Col. 3 (rejecting 20 in the index) is the cotangent of an angle F, (less than 90°,) which is to be taken out and marked *north* or *south*, with a different name from B.

6. The sum of the three logarithms in Col. 2 (rejecting 20 in the index) is the cosine of the angle C, which is to be taken *less* than 90° if B is less than 90°, but *greater* than 90° if B is *greater* than 90°. The angle C, and its cosecant, are to be placed in Col. 1.

7. Place the altitudes below C, take the *half-sum* of these three quantities, subtract the greatest altitude from the half-sum, and note the *remainder*. Place the secant of the *least* altitude in Col. 1, its cotangent in Col. 2, its sine in Col. 3; the cosine of the *half-sum* in Col. 1, and the sine of the *remainder* in Col. 1. The sum of the four

* The hour angle is the same as the elapsed time in double altitudes of the sun. This time is turned into degrees by Table XXI., but it is more simple to *double* the hour angle, and find it in Col. P. M., Table XXVII., and take out its corresponding tangent. If this double angle exceeds 12h, reject 12h, and find the remainder in Col. A. M., and take out its corresponding tangent. In the following examples this *double angle* is marked with the letters P. M. annexed.

† This rule is easily remembered in three places in which it occurs, from the circumstance that *s* is the first letter of *sum* and *same*, and *d* the first letter of *difference* and *different*.

‡ If the sum be taken to find B, and it exceed 180°, subtract it from 360°, and call the remainder B with a different name from that of A, D.

Digitized by Google

last logarithms of Col. 1, (rejecting 20 in the index,) being divided by 2, gives the sine of an acute angle, which being found and doubled, gives the zenith angle Z, which is to be named *north* if the zenith and *north* pole are on the *same* side of the arc or *great circle*, passing through the two objects, (or the two observed places of the same object,) but *south* if the zenith and *south* pole are on the *same* side of that great circle.*

8. Take the *sum* of the angles Z and F if they are of the *same* name, but their difference if of *different* names; this sum or difference is the angle G, to be marked *north* or *south*, like the greatest of the angles Z, F.† The sine of G is to be placed in Col. 2.

9. The sum of the two lower logarithms of Col. 2 (rejecting 10 in the index) is the tangent of an angle I, which is to be taken out (less than 90°) and marked *north* or *south* like G. The secant of I is to be placed in Col. 3.

10. Write the declination D, corresponding to the *least* altitude below I, take their *sum* if of the *same* names, their *difference* if of *different* names. This sum or difference is the angle K, of the same name as the greater of these two quantities. The sine of K is to be placed in Col. 3.

11. The sum of the three last logarithms in Col. 3, rejecting 20 in the index, is the sine of the required latitude, of the same name as K.

EXAMPLE XIII.

Given the sun's correct central altitude 41° 33', and his declination 14° N. After an interval of 1^h 30^m, by watch, his correct central altitude was 50°, and his declination 13° 58' N. Required the latitude, the sun being south of the observer when on the meridian.

Col. 1.	Col. 2.	Col. 3.
Hour ang. H 1h 30m [P.M. 3h] Sec. 10.03438	....	.... Tan. 9.61772
Decli. d. [at gr. alti.] 13° 58' N. Tan. 9.39569	....................Sine 9.38266	
A [dif. name from d.] 15 04 S. Tan. 9.43007	A [same aff. as H.] Cosec. 10.58512	.........Cosine 9.98431
D Dec. [at least alt.] 14 00 N.		
B.............. 1 04 S.	..................Cosine 9.99992	..........Cosec. 11.73012
C. ....21 49 Cosec. 10.42988	C [same aff. as B.] Cosine 9.96770	F 2° 40' N. Cotan. 11.33215
		Z 57 18 N. [F less than 90°, diff. name from B.]
	G..................Sine 9.93738	G 59 58 N.
Least altitude........41 33 Sec. 10.12588	..................Cotan. 10.05243	.............Sine 9.82169
Greatest altitude..... 50 00	I 44° 20' N. Tan. 9.98981	[I less than 90°] Sec. 10.14552 [I named as G.]
Sum...............113 22	Dec. D. 14 00 N. [at least alt.]	
½ Sum............ . 56 41 Cosine 9.73978	K 58 20 N.	.............Sine 9.92999
½ S.—gr. alt. = Rem. 6 41 Sine 9.06589		Latitude.....52 7 N. Sine 9.89720
Sum 4 logs. 2)19.36143		
½ Z.................28 39 Sine 9.68071		
Z.................. 57 18 N. [named like bearing of zenith.]		

If the latitude had been south, Z, instead of being 57° 18' *north*, would be 57° 18' *south*; G = 54° 38' S., I = 42° 37' S., K = 28° 37' S., and the latitude 25° 34' S. The labor of making this extra calculation is but little, and where any doubt exists of the *name* of Z, it is best to make the computation both ways; this, however, will rarely happen. The calculations of this example, and most of the following ones, are made to the nearest minute; where great accuracy is required, it will be proper to take the logarithms and angles corresponding to seconds.

* This case occurs also in the first and second methods of solution, and it must be determined on the spot by the situation of the objects. In double altitudes of the sun, moon, or planets, when the elapsed time is not very great, the angle Z is generally to be marked with the bearing of the zenith from the observed object, when *at its greatest altitude* on the meridian, which in north latitudes, without the tropics, is in general *north*; in south latitudes, without the tropics, *south*. Sometimes, when the sun passes the meridian near the zenith, it may be doubtful whether the zenith be *north* or *south*; in which case the problem may be solved for *both* cases, (which increases the labor but little,) and that one of the two computed latitudes selected which agrees best with the ship's reckoning; but it is generally safest not to use observations of this kind, which are generally liable to great errors from small mistakes in the altitudes.

† If the *sum* be taken to find G, and it exceed 180°, subtract it from 360°, and call the remainder G, with a *different* name from Z or F.

Digitized by Google

EXAMPLE XIV.

The sun's correct central altitude was 32° 25′, his declination 17° 0′ S., 8 hours afterwards, by a watch, the sun's correct central altitude was 30° 8′ and declination 16° 55′ S., the observer being in a high south latitude; required the latitude.

Col. 1.	Col. 2.	Col. 3.
Hour H 8h [P.M. 16h=4h A.M.] Sec. 10.30103	....	............Tan. 10.23856
Decli. d. [at gr. alti.] 17° 00′ S. Tan. 9.48534	....................Sine 9.46594	
A[dif.name from d.] 14[illegible] [illegible]3 N. Tan. 9.78637	A [same aff. as H.] Cosec. 10.28253	...........Cosine 9.93100
D Dec. [at least alt.] 16 55 S.		
B.............. 131 38 N.	..................Cosine 9.89240	...........Cosec. 10.12644
C.............. 111 51 Cosec. 10.03238	C [same aff. as B.] Cosine 9.57087	F 26° 50′ S. Cotan. 10.29600
		Z 25 46 S. [F less than 90°, dif. name from B.]
	G...................Sine 9.90005	G 52 36 S.
Least altitude....... 30 08 Sec. 10.06305	.. ..Cotan. 10.23693	.............Sine 9.70072
Greatest altitude.... 32 25	I 53° 51′ S. Tan. 10.13628	[I less than 90°] Sec. 10.22922 [I named as G.]
Sum................174 24	Dec. D 16 55 S. [at least alt.]	
½ Sum.............. 87 12 Cosine 8.68886	K 70 46 S..................	.............Sine 9.97506
½ S —gr. alti.=Rem. 54 47 Sine 9.91221		Latitude.....53 26 S. Sine 9.90500
Sum 4 logs. 2)18.69650		
½ Z.................. 12 53 Sine 9.34825		
Z.................. 25 46 S. [named like bearing of zenith.]		

This latitude differs 3′ from the calculation in Example XI, page 191, on account of not noticing the seconds in the angles.

If the zenith had been north of the great circle passing through the sun and moon, we should have Z = 25° 46′ N., G = 1° 04′ S., I = 1° 50′ S., K = 18° 45′ S., and the latitude 9° 18′ S.

EXAMPLE XV.

Suppose, at the same moment of time, the moon's correct central altitude was 55° 20′, the moon's declination 0° 36′ N., the sun's correct central altitude 37° 40′, the sun's declination 0° 17′ S.: the hour angle, or difference of the right ascensions of the sun and moon, being, by the Nautical Almanac, 5 hours, or 75°. Required the latitude, supposing it to be north.

Col. 1.	Col. 2	Col. 3.
Hour angle H 5h [P. M. 10h] Sec 10.58700	....	..............Tan. 10.57196
Decli. d. [at gr. alt.] 0° 36′ N. Tan. 8.02004	....................Sine 8.0[illegible]	
A [dif. name from d.] 2 19 S. Tan. 8.60704	A [same aff. as H.] Cosec. 11.39338	...........Cosine 9.99964
D Decl. [at least alt.] 0 17 S.		
B.............. 2 36 S.	..................Cosine 9.99955	...........Cosec. 11.34330
C.............. 75 00 Cosec. 10.01506	C [same aff. as B.] Cosine 9.41295	F 0° 42′ N. Cotan. 11.91489
		Z 29 40 N. [F less than 90°, dif. name from B.]
	G...................Sine 9.70375	G 30 22 N.
Least altitude...... 37 40 Sec. 10.10151	.................Cotan. 10.11941	.............Sine 9.70609
Greatest altitude... 55 20	I 33° 13′ N. Tan. 9.81616	[I less than 90°] Sec. 10.07748 [I named as G.]
Sum.............. 168 00	Dec. D. 0 17 S. [at least alt.]	
½ Sum............ 84 00 Cosine 9.01923	K 32 56 N.	.............Sine 9.73533
½ S.—gr. alt.=Rem. 28 40 Sine 9.68096		Latitude.....23° 24′ N. Sine 9.59890
Sum of 4 logs. 2)18.81678		
½ Z................ 14 50 Sine 9.40839		
Z.................. 29 40 N. [named like bearing of zenith.]		

This latitude agrees with the calculation in Example XII., page 192

If the zenith had been south of the great circle passing through the objects, we should have Z = 29° 40′ S., G = 28° 58′ S., I = 32° 6′ S., K = 32° 23′ S., and the latitude 22° 44′ S

Digitized by Google

EXAMPLE XVI.

Given the moon's correct central altitude 47° 37′, the moon's declination 17° 29′ S, the sun's correct central altitude, at the same time, 27° 22′, the sun's declination 8° 28′ S., the hour angle, or difference of right ascensions of the sun and moon, $5^h\ 40^m\ 28^s$, or 85° 7′; required the latitude, supposing it to be north.

Col. 1.	Col. 2.	Col. 3.
Hr. H 85° 7′ [P.M. 11^h 20′ 56″] Sec. 11.06993	....	............Tan. 11.06835
Decli. *d.* [at gr. alt.] 17° 29′ S. Tan. 9.49828	....................Sine 9.47774	
A [dif. name from *d.*] 74 53 N. Tan. 10.56821	A [same aff. as H.] Cosec. 10.01529	..........Cosine 9.41626
D Decl. [at least alt.] 8 28 S.		
B............. 66 25 N.	..................Cosine 9.60215	..........Cosec. 10.03788
C............. 82 51 Cosec. 10.00339	C [same aff. as B.] Cosine 9.09518	F 16° 43′ S. Cotan. 10.52251
		Z 39 20 N. [F less than 90°, diff. name from B.]
	G.................. Sine 9.58497	G 22 37 N.
Least altitude...... 27 22 Sec. 10.05155	..................Cotan. 10.28599	............Sine 9.66246
Greatest altitude... 47 37	I 36° 37′ N. Tan. 9.87096	[I less than 90°] Sec. 10 09548 [I named as G.]
Sum...............157 50	Dec. D. 8 28 S. [at least alt.]	
½ Sum............. 78 55 Cosine 9.28384	K 28 09 N................	..............Sine 9.67374
½ S.—gr. alt.=Rem. 31 18 Sine 9.71560		Latitude 15° 41′ N. Sine 9.43168
Sum of 4 logs. 2) 19.05438		
½ Z... .... 19 40 Sine 9.52719		

Z.................. 39 20 N. [named like the bearing of zenith.]

If the zenith had been south of the great circle passing through the objects, we should have Z = 39° 20′ S., G = 56° 3′ S., I = 58° 2′ S., K = 66° 30′ S., and the latitude 52° 46′ S.

FIFTH METHOD.

To find the latitude from the altitudes and distances found in taking a lunar observation.

This is a particular case of Form V., and is more simple than the general solution, because the true distance of the objects, computed in working the lunar observation, may be used to shorten the calculation of the latitudes; we shall therefore give a particular rule for this method.

Having the *apparent* altitudes and distance of the objects, find, by any of the methods of working a lunar observation hereafter given, the *true* distance. Find also the *true* altitudes, by correcting the apparent altitudes for parallax and refraction. The correction of the moon's altitude is equal to the *difference* between 59′ 42″ and the correction already found from Table XIX., in working the lunar observation; this *difference*, added to the moon's apparent altitude, gives her *true* altitude. In like manner the correction of the sun's altitude is equal to the difference between 60′ and the correction already found in Table XVIII. (or in Table XVII. if a star or planet is used); this difference is to be subtracted from the sun's (or star's) apparent altitude, to obtain its *true* altitude. The time at Greenwich, corresponding to the *true* distance, having been found in working the lunar observation, take from the Nautical Almanac, for this time, the declinations of the sun and moon, as is taught in pages 156, 171. If, instead of the sun, a star is used, its declination may be obtained from Table VIII., or more accurately from the Nautical Almanac, if it be one of the 100 bright stars whose places are now given for every ten days in that work. If a planet is used, its declination is to be found in the Nautical Almanac. From these declinations, the *north polar distances* must be found, by *adding* the declinations to 90° if *south*, or *subtracting* from 90° if *north*.

Having thus obtained the *true* distance, the *true* altitudes, the declinations and north polar distances, the latitude may be computed by the following rule, adapted exclusively to Table XXVII., writing, as before, sine, cosine, &c., for log. sine, log. cosine, &c., the logarithms being arranged in three columns, as in the former methods.

RULE.

1. Place in Col. 1 the *true* distance and the polar distances. Take their *half-sum* subtract from this half-sum the polar distance of the object which had the greatest altitude, and note the *remainder*. Put in the same column the cosecant of the true distance, the cosecant of the polar distance of the object having the least altitude, the sine of the *half-sum*, the sine of the *remainder*. The sum of these four logarithms (rejecting 20 in the index) being divided by 2, gives the sine of an acute angle, which being found and doubled, is to be called the angle F

Digitized by Google

2. Place in Col. 1 the true distance and the true altitudes. Take their *half-sum*, and also the *remainder* or difference between the half-sum and the greatest altitude Place in the same column the cosecant of the distance, (before found,) the secant of the least altitude, the cosine of the *half-sum*, the sine of the remainder. The sum of these four logarithms (rejecting 20 in the index) being divided by 2, gives the sine of an acute angle, which being found and doubled, is to be called the angle Z.

3. If the zenith and *north* pole be situated on the *same* side of the great circle, passing through the two objects,* take the *sum*† of the angles F and Z for the angle G; but if the zenith and *north* pole be situated on *different* sides of that great circle, take their *difference* for the angle G. Place the cosine of G in Col. 2.

4. Write in Col. 2 the cotangent of the least altitude, and its sine in Col. 3.‡ The sum of the two logarithms in Col. 2, is the tangent of the angle I, which is to be taken less than 90°, and marked *south* if the angle G is *less* than 90°, but *north* if G is *more than* 90°. Place the secant of I in Col. 3.

5. Place the declination corresponding to the least altitude, below I; take their *sum* if of the *same* name, but their *difference* if of *different* names; call this sum or difference the angle K, and mark it with the same name as the greatest of the two quantities. Place the sine of K in Col. 3.

6. The sum of the three logarithms in Col. 3 (rejecting 20 in the index) is the sine of the latitude, of the same name as K.

Having found the latitude, the hour may be obtained by means of the true altitude and declination of the sun, star, or planet, by any of the usual methods hereafter given for that purpose; but, if the last of the observed altitudes was that of the sun, star, or planet, the horary distance of that object from the meridian might be obtained more simply by the following rule, adapted to Table XXVII.

RULE. Add the tangent of the angle G, the sine of the angle I, the secant of the angle K; the sum, rejecting 20 in the index, is the tangent of an angle; take out the corresponding time in the column P. M. or in the column A. M. increased by 12 hours; half of either of these times is the horary distance of the lowest observed object from the upper or lower meridian, whence the hour may be obtained directly if it be the sun, but if it be the star, a planet, (or the moon,) it is obtained by applying its horary distance to the hour of passing the meridian, according to the usual methods of finding the time from an altitude of a fixed star or the moon.

EXAMPLE XVII.

[Same as Dr. Brinkley's, in the N A., 1825.]

May 19d 8h 6m, P. M., in the longitude of 7h 23m west, it was found, by working a lunar observation, that the correct distance of the centres of the sun and moon was 90° 57′ 20″; true altitude of the sun's centre 11° 33′ 12″; true altitude of the moon's centre 27° 32′ 18″. At the same time, by the Nautical Almanac, the sun's declination was 19° 56′ 48″ N., the moon's declination 13° 55′ 48″ N Required the latitude and hour by this observation.

Col. 1			Col. 2			Col. 3
True distance	90° 57′ 20″	Cosec. 10.00006				
P. dist. at le. alt.	70 03 12	Cosec. 10.02687				
P. dist. at gr. alt.	76 04 12					
Sum..........	237 04 44		G is *sum* of F, Z, if *north* pole and *zenith* are on *same* side of great circle, but their *difference* if on different sides.			
½ Sum........	118 32 22	Sine 9.94374				
½S.—p.d.at gr.al.	42 28 10	Sine 9.82943				
		2) 19.80010				I is less than 90°, named south if G is less than 90°, north if G is more than 90°.
½ F............	52 36 00	Sine 9.90005	Z	61° 36′ 52″		
Angle F.......	105 12 00		F	105 12 00		
True distance..	90 57 20	Cosec. 10.00006	G	166 48 52	Cosine 9.98840	
Least alt	11 33 12	Sec. 10.00888	....		Cotan. 10.68947	..............Sine 9.30168
Greatest alt.....	27 32 18		I	78 08 33 N.	Tan. 10.67787	..............Sec. 10.68723
Sum..........	130 02 50		Dec.	19 56 48 N. (at least alt.)		
½ Sum.........	65 01 25	Cosine 9.62557	K	98 05 21 N.	....	Sine 9.99566
½ Sum—gr. alt	37 29 07	Sine 9.78430			Latitude 74° 48′ N.	Sine 9.98458
		2) 19.41881				
½ Z............	30 48 26	Sine 9.70940				
Angle Z.......	61 36 52					

* In places without the tropics, the *sum* is used generally in *northern* latitudes, and the *difference* in *southern* latitudes.

† If this sum should exceed 180°, subtract it from 360°, and call the remainder the angle G.

‡ Both these logarithms may be taken out at the same time when the sine of the angle was found in the computation of the angle Z

Digitized by Google

To find the hour.

G...	Tan.	9.36974
I...	Sine	9.99063
K...	Sec.	10.85166
Hour P. M. $7^h\ 47^m\ 42^s$, or A. M. + $12^h = 16^h\ 12^m\ 18^s$.......	Tan.	10.21203

Divided by 2, gives the horary distance of the lowest object from the meridian, } $3^h\ 53^m\ 51^s$, or $8^h\ 06^m\ 09^s$.

The sun being at the lowest altitude, his distance from the *upper* meridian was $8^h\ 6^m\ 9^s$, being the hour of the day, and the sun's distance from the lower meridian, or midnight, was $3^h\ 53^m\ 51^s$.

ADDITIONAL QUESTIONS FOR EXERCISE.

In the following questions the sun's semidiameter is supposed to be 16′, and the parallax nothing.

1. Being at sea, in latitude by account 39° 28′ N., when the sun's declination was 20° 41′ N., at $11^h\ 30^m\ 15^s$, A. M., per watch, the altitude of the sun's lower limb was observed to be 68° 18′ 45″, and at $12^h\ 26^m\ 28^s$ P. M. was 70° 58′, the height of the eye being 21 feet above the surface of the sea. Required the true latitude of the ship.
Answer, 39° 28′ N.

2. Being at sea in latitude 50° 40′ N. by account, at $10^h\ 17^m\ 30^s$, A. M., per watch, the altitude of the sun's lower limb was observed to be 17° 4′¼, and at $11^h\ 17^m\ 30^s$ was 19° 31′¼, the declination being 20° S., and the height of the eye 21 feet above the sea. Required the latitude in.
Answer, 50° 1′ N.

3. Suppose a ship at sea, in latitude 47° 34′ N. by account, and that at $9^h\ 55^m\ 30^s$, by watch, the altitude of the sun's lower limb was 17° 24′, bearing by compass S. by E. ¼ E., and at $12^h\ 54^m\ 10^s$ the altitude of the same limb was 21° 45′½, the declination being 19° 30′ S., the height of the eye 20 feet above the sea, and the ship's course by compass E. ½ S., at the rate of 7 knots per hour. What was the true latitude?
Answer, 47° 24 N.

4. At $11^h\ 28^m\ 20^s$, A. M., per watch, the altitude of the sun's lower limb was 28° 18′, the sun bearing S. by W. by compass. At $2^h\ 58^m\ 20^s$, P. M., the altitude of the same limb was 16° 40′, the height of the eye 20 feet, his declination 13° 17′ S., and the latitude by account 47° 50′ N., the ship's course during the elapsed time N. E., with her larboard tacks on board,* sailing at the rate of 6 knots, and making half a point lee-way. What latitude was she in when the last altitude was taken?
Answer, 48° 9′ N.

* The larboard side of a ship is the left side, when the observer is aft, looking towards her head, and the starboard is the right side. When a ship is sailing with her larboard tacks on board, the lee-way is allowed to the right hand; but if her starboard tacks are on board, to the left hand.

In calculating the answers to these questions, proportional parts were taken for the seconds; a small difference would be found if the nearest logarithms only were taken.

Digitized by Google

TO FIND THE LATITUDE BY ONE ALTITUDE OF THE SUN TAKEN NEAR NOON, HAVING THE TIME OF OBSERVATION.

When the sun does not pass near the zenith, the meridian altitude and the latitude of the place may be accurately determined by observing his altitude when near the meridian, and noting the time by a watch regulated the preceding morning or following evening, by either of the methods given in this work.* To this time by the watch must be applied a correction equal to the difference of longitude made by the ship (turned into time) in the interval between the regulation and the observation near the meridian, by *adding when the place of regulation is to the westward of the place of taking the other observation, otherwise by subtracting;* the sum or difference will be the time of taking the observation; whence the time from noon will be obtained; with which, and the observed altitude, (corrected for semidiameter, dip, &c., as usual,) the sun's declination, (found in Table IV., or in the Nautical Almanac, and corrected for the longitude of the ship,) and the latitude by account, the latitude by observation may be found as follows:—

RULE.

Add together the log. cosine of the latitude by account, (Table XXVII.) the log. cosine of the declination, (Table XXVII.) the logarithm in the column of rising, (Table XXIII.) corresponding to the apparent time from noon when the observation was taken; reject 20 in the index; the natural number of the remainder being found, (in Table XXVI.) and added to the natural sine of the observed altitude, (Table XXIV.) the sum will be the natural cosine of the meridian zenith distance, from which the latitude may be obtained by the common rules

If the computed latitude differs considerably from the latitude by account, it is best to repeat the operation, using the latitude last found instead of the latitude by account. This method of finding the latitude by a single altitude of the sun, may be applied to any other celestial object.

EXAMPLE I.

Being at sea, in latitude 49° 50′ N. by account, when the sun's declination was 20° S., at $11^h\ 29^m\ 20^s$, A. M., apparent time, per watch, regulated the preceding morning, in a place 20 miles of longitude to the eastward, the sun's correct central altitude was 19° 41′,† bearing south. Required the true latitude.

Time per watch......	$11^h\ 29^m\ 20^s$		
20′ in time by Tab. XXI.	1 20		
Time of observation..	11 28 0	Latitude 49° 50′	Cosine 9.80957
	12	Declin. 20 0	Cosine 9.97299
App. time from noon..	32 0	....	Log. rising 2.98820
		Nat. Num. 590 log.	2.77076
		Central altitude 19° 41′ Nat. Sine	33682
		Mer. zen. dist. 69 57 N. Nat. Cosine	34272
		Declination 20 0 S.	
		Latitude.... 49 57 N.	

* The best time for regulating a watch is when the sun bears nearly east or west, and is above 10° from the horizon.

† The observed altitude of the lower limb being 19° 32′, ☉'s semidiameter 16′, dip 4′, refraction 3, parallax too small to be noticed

Digitized by Google

EXAMPLE II.

At sea in the latitude of 60° N. by account, the sun being on the equator, at $0^h\ 59^m\ 0^s$, P. M., per watch, regulated to apparent time the preceding morning in a place 15 miles in longitude to the westward, the sun's correct central altitude * was 28° 53′, bearing south. Required the latitude.

App. time per watch	$0^h\ 59^m\ 0^s$	Latitude	60° N.	Cosine	9.69897
15′ long. in time....	1 0	Declination	0	Cosine	10.00000
App. time from noon	1 0 0	...............Corresponding log. rising			3.53243
		Nat. Numb..	1704	Log.	3.23140
Central altitude....	28° 53′	Nat. Sine...	48303		
Mer. zenith distance	60 0 N.	Nat. Cosine.	50007		
Declination.	0 0				
Latitude..........	60 0 N.				

When the observation is taken a few minutes before or after noon, the correction to be applied to the altitude, to obtain the meridian altitude, may be found by means of Tables XXXII. and XXXIII., the first of which contains the variation of the altitude for one minute from noon, expressed in seconds and tenths; the other contains the square of the minutes and seconds of a minute contained in the top and the side columns. By these tables the correction of the observed altitude may be found by the following rule:—

RULE.

Enter Table XXXII., and find the latitude by account in the side column, and the declination at the top, opposite the former, and under the latter, will be the change of altitude in seconds and tenths for one minute from noon: then enter Table XXXIII., and find the minutes of the apparent time from noon in the top column, and the seconds in the side column; under the former, and opposite the latter, will be a number which is to be multiplied by the number taken from Table XXXII., and the product will be the sought change of altitude, expressed in seconds and decimals.

In making use of Table XXXII., proportional parts may, if necessary, be taken for the miles of latitude and declination. The numbers in both these tables are expressed in whole numbers and tenths.

EXAMPLE III.

Being at sea in the latitude of 40° N. when the sun's declination was 21° N., at 8^m past noon, apparent time, the sun's correct central altitude † was 70° 58′. Required the meridian altitude and latitude.

In Table XXXII., opposite 40° lat., and under 21° dec., is 4″.3, and the number in Table XXXIII. corresponding to 8^m is 64.0. Multiplying 64.0 by 4″.3, we get the correction 275″.2 (or 5 nearly). This quantity, being added to 70° 58′, gives the meridian altitude 71° 3′; and the latitude deduced therefrom is 39° 57′ N.

By observing several altitudes of the sun when near the meridian, and noting the times, the meridian altitude may be obtained, by the above method, to a great degree of accuracy. For by using this method, many observations may be taken on the same day, and the mean of the meridian altitudes deduced therefrom will in general be much more correct than that obtained by a single observation, by the usual method. To obtain the correction to be applied to the mean of all the observed altitudes, proceed thus:—

Take from Table XXXIII. the number corresponding to each time from noon, (the minutes being found at the top and the seconds at the side, the correction being under the former and opposite the latter,) and divide the sum of these tabular numbers by the number of observations; the quotient, being multiplied by the number taken from Table XXXII., will be the correction to be applied to the mean of the observed altitudes, to obtain the meridian altitude.

EXAMPLE IV.

Being at sea in the latitude of 50° N. by account, when the sun's declination was 22° N., observed with a sextant, the altitudes of the sun's lower limb (bearing nearly

* The observed altitude of the sun's lower limb being 28° 43′, ☉'s S. D. 16′, dip 4′, refraction 2′ parallax too small to be noticed.

† The observed altitude of the sun's lower limb being 70° 46′, semidiameter 16′, dip 4′, parallax and refraction too small to be noticed.

Digitized by Google

south) as in the following table; the correction for semidiameter, dip, refraction, &c., being 12′ additive. Required the meridian altitude and latitude.

Obs. Alt. ☉ L. L.	*App. Time from Noon.*	*Numbers Tab.*
° ′	m s	
61.45	6 10	38.0
61.46	4 15	18.1
61.46	3 2	9.2
61.47	2 10	4.7
Sum 247.04		70.0
Mean 61.46		17.5

The mean of the numbers from Table XXXIII. is 17.5; this being multiplied by the number of seconds from Table XXXII., viz. 2″.5, gives the correction 43″.75, or 44″, which, being added to the mean of the observed altitudes, 61° 46′, gives the meridian altitude of the sun's lower limb, 61° 46′ 44″, or 61° 47′ nearly; to this add 12′ for semidiameter, &c., and we get 61° 59′ for the correct central meridian altitude, whence the latitude is 50° 1′ N.

If the above altitudes had been taken with a circle, the calculation would have been exactly the same, except that each altitude would not have been given, but the sum of all of them, 247° 4′, would have been shown by the central index after finishing the observations.

EXAMPLE V.

Having regulated my watch, I found it to be 6m 2s too slow for apparent time. I then sailed to the southward and eastward till the ship had made 60′ difference of longitude, and was by account in the latitude of 40° N., the sun's declination being 20° S. The sun being then nearly on the meridian, I observed ten altitudes of his lower limb by a circle of reflection, and noted the times by the watch as in the following table; and the sum of all the altitudes taken from the circle was 298° 20′. Required the true latitude, supposing the dip to be 4′ and the semidiameter 16′.

When it was 12 o'clock by the watch, it was 12h 6m 2s apparent time at the place where the watch was regulated, and 12h 10m 2s apparent time at the place where the altitudes were taken to determine the latitude, because the former place was 60′ or 4m in time to the westward of the latter; consequently the watch was 10m 2s too slow for apparent time at the place of taking the altitudes for determining the latitude. Hence we may determine the time from noon of taking each observation, as in the second column of the adjoined table, and find the numbers corresponding in Table XXXIII., the mean of which is 6.97; this, multiplied by the number in Table XXXII. corresponding to the latitude 40° N. and declination 20° S., viz. 1″.6, will give 11″.152 or 11″, which is the correction to be added to the mean of the observed altitudes to obtain the meridian altitude.

Time per Watch.	*App. Time from Noon.*	*Numbers Tab. XXXIII.*
11.45 43	4′ 15″	18.1
46.58	3 0	9.0
47.52	2 6	4.4
48.50	1 8	1.3
49.28	0 30	0.2
50.48	0 50	0.7
51.10	1 12	1.4
52.13	2 15	5.1
53. 8	3 10	10.0
54.23	4 25	19.5
	Sum	69.7
	Mean	6.97

Now the sum of all the altitudes 298° 20′, being divided by 10, the number of observations, gives........................... 29° 50′ 0″
Add semidiameter 16′ and the above correction 11″...... + 16 11
Add parallax found in Table XIV.................... + 8
Subtract dip 4′ and refraction 1′ 39″ .... − 5 39

Central altitude....................................	30 0 40
Zenith distance....................................	59 59 20 N.
Declination..	20 0 0 S.
Latitude...	39 59 20 N.

When the meridian altitude of the object is small, the correction of altitude may be found by this method, for 12 or 15 minutes from noon, to a great degree of accuracy; but when the sun passes near the zenith, the time of observation must be proportionally nearer to noon. Thus, in Example I., preceding, the time from noon was 32′, and as the numbers in Table XXXIII. are the squares of the number of minutes, it follows, that the number corresponding to 32m would be the square of 32, or 1024.0. This, being multiplied by the number 1″.3 of Table XXXII., corresponding to the latitude 50° N. and declination 20° S., will give the correction 1331″.2, or nearly 22′

Digitized by Google

which, being added to 19° 41′, will give 20° 3′ for the meridian altitude, or 69° 57′ for the zenith distance, being the same as in that example.

It is very advantageous in this method to observe as many altitudes in the afternoon as before noon, and at nearly the same distances from noon; for in this case a small error in the regulating of the watch will not materially affect the calculation. This will appear evident by supposing, in the preceding example, that the watch was $11^m\ 2^s$ too slow, instead of $10^m\ 2^s$; by this means the times and numbers will be as in the adjoined table, and the mean of all the numbers, taken from Table XXXIII., will be 8.15, which, being multiplied by $1^s.6$, will give 13^s nearly, for the correction, instead of 11^s, so that in this case an error of one minute in the regulation of the watch would only cause an error of 2 seconds in the meridian altitude.

Times.	*In Tab. XXXIII.*
3.15	10.6
2.00	4.0
1.06	1.2
0.08	0.0
0.30	0.2
1.50	3.4
2.12	4.8
3.15	10.6
4.10	17.4
5.25	29.3
Sum	81.5
Mean	8.15

But it must be carefully observed, that, in using this method, you must not take the observation more than 2 or 3 minutes from noon, when the sun passes within 10° or 12° of the zenith.

Digitized by Google

TO DETERMINE THE LATITUDE ON SHORE BY MEANS OF AN ARTIFICIAL HORIZON.

It frequently happens that the latitude of a place on shore cannot be determined by the usual methods, by a quadrant, sextant, or circle, on account of not having an open horizon. In this case it is customary to make use of an artificial horizon formed by the surface of a vessel filled with mercury, water, Barbadoes tar, very clear molasses, or any other fluid of sufficient consistency not to be affected by the wind.* With this apparatus an observation may be taken on shore when the altitude of the object does not exceed 60°, with as much ease as at sea. Thus, if an altitude of the sun was required to be taken, the observer must place the vessel containing the mercury (or other fluid) in a firm position on the ground, and in a few minutes the surface of the liquor will attain a horizontal situation; the observer must then place himself in a situation so as to see the image of the sun, formed by the fluid, which image will evidently be depressed as much below the horizon as the sun is elevated above it, so that, to obtain the double of the sun's altitude, it is only necessary for the observer to bring the image of the sun, formed by the instrument, down to the image formed by the artificial horizon, and the angle then pointed out by the index will be double of the altitude of the sun; the half of which will be the apparent altitude. If the nearest limbs of the two images are brought in contact, the half of the angle obtained by the instrument will be the altitude of the sun's lower limb, but if the farthest limbs are brought in contact, the half angle will be the altitude of the upper limb. The altitude thus obtained must be corrected for semidiameter, parallax, and refraction, as usual, but not for dip, because a truly horizontal surface is obtained by means of the artificial horizon.† In this manner the altitude of the sun, or any other bright object may be obtained when the altitude is less than 60°; at higher altitudes the angle corresponding would be above 120°, which cannot be measured by a sextant on account of the length of the arc, nor by any other instrument of reflection, in a convenient manner, with a sufficient degree of accuracy. To illustrate this method we shall here add the following examples:—

EXAMPLE I.

The angular distance of the nearest limbs of the two images of the sun was found by the above method to be 68° 10′, when the declination was 10° S., and the sun's semidiameter 16′, the sun bearing south of the observer. Required the latitude:—

Half of 68° 10′ is the obs. alt.	34° 5′
Add semidiameter	16
	34 21
Subtract refraction	1
True altitude	34 20
Zenith distance	55 40 N.
Declination	10 0 S.
Latitude	45 40 N.

EXAMPLE II.

The angular distance of the farthest limbs of the two images of the sun, when on the meridian, was obtained by the above method, and found to be 34° 0′, when the declination was 10° N., and the semidiameter 16′; the sun bearing north of the observer. Required the latitude:—

Half of 34° 0′ is the obs. alt.	17° 0
Subtract semidiameter	16
	16 44
Refraction sub.	3
True altitude	16 41
Zenith distance	73 19 S.
Declination	10 0 N.
Latitude	63 19 S.

* In case the wind blows fresh, you must use a screen formed of two plates of talc or glass whose surfaces are ground perfectly parallel, and connected together in a frame so as to make an angle of about 90° with each other. This frame is to be placed over the box containing the fluid, and the rays of the sun, passing through one of the plates, are reflected from the surface of the liquor, and pass through the other plate to the eye of the observer. The use of these plates is to be avoided, when it can possibly be done, on account of the defect of parallelism of the surfaces. This error is generally greatest near the border of the glass, so that it has been recommended to cover the edge of the glass with a paper or some paint, to the distance of ¼ or ½ inch from the frame. If the surfaces of the glass are perfectly parallel, the observed angle will be the same as if the screen had not been used. Instead of using the screen we may place one of the glasses of the screen upon the surface of the fluid, which will prevent it from being agitated by the wind, or other similar causes. If the reflecting fluid is molasses, air-bubbles will sometimes rise on the surface by the sun's heat; this may in some measure be avoided by heating the molasses before using it.

† If the instrument has an index error, it must be applied to the observed angle, or the half of the index error must be applied to the sun's altitude

Digitized by Google

The latitude may be determined on shore by this method to a great degree of accuracy by means of a circle of reflection, by taking several altitudes a few minutes before and after the sun passes the meridian, and estimating the correction to be applied to the altitude by means of Tables XXXII. and XXXIII. Thus, if, in the example page 202, the observations had been taken in this manner, the number of degrees denoted by the circle after taking ten observations, would have been 595° 20′; this, being divided by 20, (twice the number of observations,) will give for the observed altitude 29° 46′ and by adding the semidiameter 16′, parallax 8″, and the correction found by Tables XXXII. and XXXIII., viz. 11 seconds, and subtracting the refraction 1′ 39″, the central altitude will be obtained, 30° 0′ 40″, as in the page before mentioned.

Altitudes may be observed in this way in taking an azimuth for determining the variation, or for regulating a watch, in the manner explained in this work; observing, in all cases, that the half of the observed angle is to be corrected for refraction, parallax, and semidiameter, but not for the dip of the horizon, and that half the index error only is to be applied.

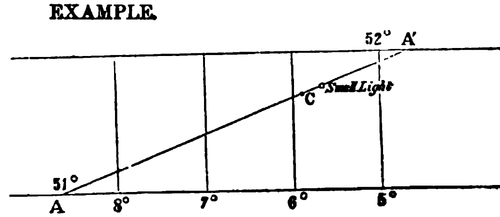
TO FIND THE POSITION* OF A SHIP ON A LINE OF BEARING.

CASE I.

When the position of a ship is unknown, the latitude by account being uncertain, assume two or more latitudes, and work out the longitudes corresponding thereto. A line drawn on a chart through the two points thus determined, will *represent the line of equal altitudes.* The place of the ship will be somewhere on this line; and if it passes through the land, the *bearing* of the land will be known. If the coast should run parallel to this line, you will have the distance of the ship from the land, but of course not the absolute position.

EXAMPLE.

December 17th, 1837.—The latitude, by account, being 51° 37′ N., the Greenwich time 10h. 47m. 13s. A. M., the true altitude of the sun's centre was found to be 12° 10′. Required the true bearing of the land.



Let the assumed latitudes be 51° and 52°, sun's declination 23° 23′ S., and the equation of time —3m. 37s.—The longitude corresponding to 51° latitude will be about 8° 42′ W.
The longitude corresponding to 52° latitude will be about 4° 50′ W.
A line drawn through these positions A A′, will represent the line of equal altitudes, and will also pass through "Small Lights," and run parallel to the S. E. coast of Ireland.

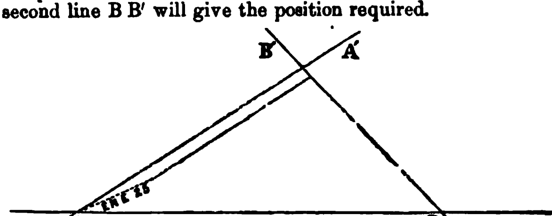
The light was seen in the course of an hour, and the error in latitude ascertained to be 8′, C being the position of the ship.

CASE II.

When a *double altitude* is taken, the position of the ship may be found by working the longitude for each altitude, as in Case I., and then drawing *two lines* of equal altitudes through the four points A A′ and B B′ thus determined. The point of intersection of said lines will give the position of the ship. The necessary correction for the *change of position*, when the second altitude was taken, must be made as explained on page 183, or by moving the line A A′ projected (parallel to itself) along the course and distance made good by the ship. Thus, suppose between the observations the ship had sailed E. N. E. 25 miles. Then move the first line A A′ parallel to itself on this course 25 miles, and draw a line whose intersection with the second line B B′ will give the position required.

It is evident, that when the two lines cross each other at about right angles, the point of intersection is more easily found.

A line drawn perpendicular to the line of equal altitude shows the direction of the sun, and consequently the azimuth.



The assumed latitude must be near the truth, to give value to this method.

When the altitude is high, an error in the assumed latitude is of greater importance than when it is low.

* From Sumner's work.

Digitized by Google

TO FIND THE LATITUDE BY AN ALTITUDE OF THE POLE STAR.

Find, in the side column, the sum of the apparent time of observation, and the sun's right ascension; the corresponding number, in the middle column, will be the correction of the true altitude, on account of the distance of the star from the meridian.

If the time is found in either of these columns, the correction is subtractive.		Correction of the altitude.	If the time is found in either of these columns, the correction is additive.	
H. M.	H. M.	° ′	H. M.	H. M.
1 03	1 03	1 26	13 03	13 03
1 13	1 03	1 26	13 03	13 13
1 23	0 53	1 26	12 53	13 23
1 33	0 43	1 25	12 43	13 33
1 43	33	1 25	12 33	13 43
1 53	23	1 24	12 23	13 53
2 03	13	1 24	12 13	14 03
2 13	3	1 23	12 03	14 13
2 23	23 53	1 21	11 53	14 23
2 33	23 43	1 20	11 43	14 33
2 43	23 33	1 19	11 33	14 43
2 53	23 23	1 17	11 23	14 53
3 03	23 13	1 15	11 13	15 03
3 13	23 03	1 14	11 03	15 13
3 23	22 53	1 12	10 53	15 23
3 33	22 43	1 09	10 43	15 33
3 43	22 33	1 07	10 33	15 43
3 53	22 23	1 05	10 23	15 53
4 03	22 13	1 02	10 13	16 03
4 13	22 03	59	10 03	16 13
4 23	21 53	57	9 53	16 23
4 33	21 43	54	9 43	16 33
4 43	21 33	51	9 33	16 43
4 53	21 23	48	9 23	16 53
5 03	21 13	45	9 13	17 03
5 13	21 03	41	9 03	17 13
5 23	20 53	38	8 53	17 23
5 33	20 43	35	8 43	17 33
5 43	20 33	31	8 33	17 43
5 53	20 23	28	8 23	17 53
6 03	20 13	24	8 13	18 03
6 13	20 03	20	8 03	18 13
6 23	19 53	17	7 53	18 23
6 33	19 43	13	7 43	18 33
6 43	19 33	9	7 33	18 43
6 53	19 23	6	7 23	18 53
7 03	19 13	2	7 13	19 03
7 08	19 08	0	7 08	19 08

In northern climates, the latitude may be determined by means of an observed altitude of the pole star; provided the apparent time of observation can be ascertained within a few minutes.* This method might be frequently used at sea, when the horizon is well defined, if that star were of the first magnitude; but being only of the second or third magnitude, it is sometimes so dim that it is rather difficult to determine the altitude with precision. However, as there are times when it would be of great importance to determine the latitude within 8 or 10 miles, it was thought advisable to explain this method, which may be used when observations of the sun or moon cannot be obtained.

Having, therefore, the apparent time of observation (which must be reckoned from noon to noon in numerical succession, that is, 6^h, A. M., must be called 18^h, &c.), and the observed altitude of the star determined by a fore observation, you must subtract from the altitude the dip, which is in general 4 minutes, and the refraction, and you will obtain the true altitude of the star. Then the sun's right ascension corresponding to the given day, must be found in Table VI.,† and added to the apparent time of observation (rejecting 24 hours when the sum exceeds 24 hours); with that sum enter the adjoined table, and take out the corresponding correction, which must be added to, or subtracted from, the true altitude, according to the directions in the table; the sum or difference will be the latitude of the place of observation.

* If the star be not far from the meridian, an error of half an hour in the time would not affect the altitude above 1 or 2 miles.

† It is accurate enough to take the numbers from Table VI.; but in strictness the right ascension ought

Digitized by Google

EXAMPLE I.

At $7^h\ 9^m$ P. M., June 3, 1848, the observed altitude of the pole star was 16° 10′, the dip 4′. Required the latitude of the place of observation.

		Observed altitude	16° 10′
Hour of observation	$7^h\ 9^m$	Sub. dip 4′, refrac. 3′.......	7
☉'s right ascension	4 44	True altitude	16 3
Sum.......................	11 53.	....Correction corresponding add	1 21
		Latitude	17 24 N.

EXAMPLE II.

On the 14th September, 1848, at $2^h\ 2^m$ A. M., the altitude of the pole star was 24° 16′, when the dip was 4′. Required the latitude.

		Observed altitude	24° 16′
Hour of obs. $2^h\ 2^m$ A. M., or...	$14^h\ 2^m$	Dip 4′, refrac. 2′, sub........	6
☉'s right ascension...........	11 28	True altitude	24 10
Sum, rejecting 24^h............	1 30.	.... Corresponding correction sub.	1 25
		Latitude..................	22 45 N.

EXAMPLE III.

At 5^h P. M., December 5, 1848, the observed altitude of the pole star was 25° 15′, the dip 4′. Required the latitude of the place of observation.

		Observed altitude	25° 15′
Hour of observation..........	$5^h\ 00^m$	Sub. dip 4′, refrac. 2′........	6
☉'s right ascension	16 47	True altitude...............	25 09
Sum	21 47	.....Correction corresponding sub.	0 54
		Latitude	24 15 N.

---

to be taken from the Nautical Almanac, for the hour of observation, reduced to Greenwich time, by adding or subtracting the longitude turned into time.

This table will require a correction after a few years, on account of the variation of declination, and right ascension of the star. It corresponds nearly to the year 1860; for every year after that time you must add one quarter of a minute to the times in the side columns, and decrease the tabular corrections of altitude about $\frac{1}{300}$ part. Thus for the year 1872 the times must be increased 3^m for the 12 years, so that $1^h\ 08^m$ must be called $1^h\ 11^m$, and all the corrections of altitude must be decreased $\frac{1}{25}$ part, so that 1° 15′ must be 1° 12′ nearly, and 0° 35′ must be 0° $33\frac{1}{2}$ nearly.

TO FIND THE TIME AT SEA, AND REGULATE A WATCH, BY THE SUN'S ALTITUDE.

We have already noticed the difference between the civil, astronomical, and nautical computation of time; but as it is a subject of great importance, it may not be unnecessary again to repeat, that a civil day is reckoned from midnight to midnight, and is divided into 24 hours; the first 12 hours are marked A. M., the latter 12 hours P. M. being reckoned from midnight in numeral succession from 1 to 12, then beginning again at 1 and ending at 12. Astronomers begin their computation at the noon of the civil day, and count the hours in numeral succession from 1 to 24, so that the morning hours are reckoned from 12 to 24. Navigators begin their computation at noon, 12 hours before the commencement of the civil day, (and 24 hours before the commencement of the astronomical day,) marking their hours from 1 to 12 P. M. and A. M., as in the civil computation.

There are two kinds of time, mean and apparent. *Mean time* is that shown by a chronometer, which is always regulated to mean solar time. *Apparent time* is that shown by the sun, estimating the apparent noon to commence at the passage of his centre over the meridian of any place.* There is sometimes a difference of a quarter of an hour between mean and apparent time, owing to the unequal motion of the earth in its orbit, and the inclination of its axis. This difference is called the *equation of time*, which is given in Table IV., A., or more accurately in the Nautical Almanac. It is always necessary to take notice of the equation of time when regulating a chronometer to mean solar time, by means of an altitude or transit of the sun.

We may obtain the apparent time at sea, when the ship makes no way through the water, by observing an altitude of the sun in the morning, and again in the afternoon when at the same altitude, and noting the times by a chronometer; for the middle time between these two observations will be nearly the apparent time of the sun's passage by the meridian; hence the error of the chronometer may be found. A small correction is necessary for the variation of the sun's declination during the interval between the observations, and the method of calculating this correction will be given in this work, but this method cannot often be made use of at sea, by reason of the motion of the vessel.

The best method of obtaining the apparent time at sea, is by observing, by a fore observation, the altitude of the sun's lower limb when rising or falling fastest, or when bearing nearly E. or W.; to this altitude we must add the semidiameter and parallax, and subtract the dip, (or, instead of these three corrections, add 12',† which will answer very well for an observation taken on the deck of a common-sized vessel;) subtract also the refraction, taken from Table XII., and the remainder will be the correct altitude. The ship's latitude must be found at the time of observation by carrying the reckoning forward to that time.‡ The declination must be taken from Table IV., or from the Nautical Almanac, and corrected for the ship's longitude § and the time

* There is, as we have already observed in a note on page 147, another method of computing the time, made use of by astronomers, called *Sideral* time, in which the interval between two successive transits of a fixed star over the meridian is estimated at 24 hours, commencing the day at the time the first point of Aries is on the meridian, so that the hour in sideral time is the same as the right ascension of the meridian.

† The semidiameter is, in general, about 16', the parallax never exceeds 9'', and the dip is about 4'; and as the two former corrections are additive, and the latter subtractive, the effect of all three corrections will not differ materially from 12' additive.

‡ This must be carefully attended to, because, when the ship is sailing in a northerly or southerly direction, the latitude at the time of regulating the chronometer, may vary considerably from the observed latitude at noon.

§ The declination may also be found very easily, by taking it out for the time at Greenwich, as shown by a chronometer regulated to Greenwich time. See Tab. LVII.

Digitized by Google

of the sun from the meridian by Table V. Then, *if the latitude and declination be both north or both south, subtract the declination from 90°, and you will have the polar distance; but if one be north and the other south, add the declination to 90°, and you will have the polar distance.*

Having thus found the correct altitude, latitude, and polar distance, the apparent time of observation may be found by either of the three following methods, of which the first is the most simple, since it does not require the table of natural sines, all the logarithms being found in Table XXVII. This method is abridged by means of the table of hours affixed to the table of log. sines; in using which you must observe, that, if the sine or cosine of the logarithm sought is marked at the top of the table, the title "Hour A. M." or "Hour P. M." is also to be found at the top, and the contrary if the sine or cosine is marked at the bottom.

FIRST METHOD.

Add together the correct altitude of the sun's centre, the latitude and the polar distance; from the half-sum subtract the sun's altitude, and note the remainder. Then add together the log. secant of the latitude, (this and all the other logs. being found in Table XXVII.) the log. cosecant of the polar distance, (rejecting 10 in each index,) the log. cosine of the half-sum, and the log. sine of the remainder; half the sum of these four logarithms, being sought for in the column of log. sines, will correspond to the apparent time of the day in one of the hour columns. To this apparent time we must apply the equation of time, taken from Table IV., A., or from the Nautical Almanac, and we shall obtain the mean time of the observation.

EXAMPLE I.

Suppose that, on the 10th of October, 1864, sea account, at 8^h 21^m, A. M., per watch, in the latitude 51° 30′ N., and longitude 130° E. from Greenwich, by account, the altitude of the sun's lower limb by a fore observation, was 13° 32′, the correction for semidiameter, parallax, and dip, 12′. Required the apparent time of observation.

By Example III., page 157, the declination was 6° 40′ S.; this added to 90° gives the polar distance 96° 40′. To the sun's observed altitude 13° 32′, I add 12 minutes and subtract the refraction 4′; the remainder is the correct altitude, 13° 40′.

☉'s correct altitude..	13° 40′		
Latitude	51 30	Secant.......	0.20585
Polar distance	96 40	Cosecant....	0.00295
Sum	161 50		
Half-sum...........	80 55	Cosine......	9.19830
☉'s altitude........	13 40		
Remainder.........	67 15	Sine........	9.96483
		2)	19.37193
		Sine........	9.68596

Sine........ 9.68596 corresponding to which, in the column marked A. M., is.... 8^h 7^m 46^s, the apparent time of observation.

Equation of time, sub...........	12 56
Mean time of observation.......	7 54 50
Time per watch................	8 21 00
Watch too fast.................	26 10

EXAMPLE II.

Suppose that, on the 10th of May, 1836, sea account, at 5^h 30^m P. M., per watch, in latitude 39° 54′ N., longitude by account 35° 45′ E. from Greenwich, the altitude of the sun's lower limb, by a fore observation, was 15° 45′, the correction for dip, parallax, and semidiameter, being 12 minutes, consequently the correct altitude 15° 54′ Required the apparent time of observation.

Digitized by Google

By Example IV., page 157, the sun's declination was 17° 29′ N., which, being subtracted from 90°, leaves the polar distance 72° 31′.

☉'s altitude	15° 54′		
Latitude	39 54	Secant......	0.11511
Polar distance	72 31	Cosecant....	0.02054
Sum...............	128 19		
Half-sum...........	64 10	Cosine......	9.63924
☉'s altitude	15 54		
Remainder	48 16	Sine........	9.87288
		2)	19.64777
		Sine........	9.82388 corresponding to which,

in the column P. M., is.... $5^h\ 34^m\ 28^s$, the apparent time at the place of observation.

Equation of time, sub...	3 49
Mean time of observation	5 30 39
Time per watch.......	5 30 00
Watch too slow.......	0 00 39

EXAMPLES TO EXERCISE THE LEARNER.

1. In latitude 36° 39′ S., ☉'s declination 9° 27′ N., the altitude of the ☉'s lower limb in the morning was observed 10° 33′;* required the apparent time. Answer, $7^h\ 23^m\ 51^s$.
2. In latitude 36° 21′ S., ☉'s declination 8° 44′ N., altitude ☉'s lower limb in the morning 10° 48′;* required the apparent time. Answer, $7^h\ 22^m\ 11^s$.
3. In latitude 29° 25′ N., ☉'s declination 23° 20′ N., observed altitude of ☉'s lower limb in the afternoon 14° 58′;* required the apparent time. Answer, $5^h\ 41^m$.
4. In latitude 3° 31′ S., ☉'s declination 20° 3′ S., observed altitude ☉'s lower limb 38° 41′* in the afternoon; required the apparent time. Answer, $3^h\ 18^m\ 47^s$.
5. In latitude 13° 17′ N., ☉'s declination 22° 10′ S., in the morning observed altitude of ☉'s lower limb 36° 26′;* required the apparent time. Answer, $9^h\ 17^m\ 8^s$.
6. In latitude 21° 36′ S., ☉'s declination 3° 37′ S., in the morning observed altitude of ☉'s lower limb 35° 48′;* required the apparent time. Answer, $8^h\ 29^m\ 50^s$.

SECOND METHOD.

Find, as in the former method, the sun's correct altitude, the ship's latitude, and the polar distance; thence the sun's correct zenith distance, and the complement of latitude; then *add together the zenith distance, co-latitude, and polar distance; from half their sum subtract the zenith distance, and note the remainder. Add together the log. cosecant of the co-latitude,* (*this and all the other logs. being found in Table XXVII.,*) *the log. cosecant of the polar distance,* (*rejecting* 10 *in each index,*) *the sine of the half-sum and the sine of the remainder; half the sum of these four logarithms, being found among the log. cosines, will correspond in one of the adjoined columns to the apparent time of day. This may be reduced to mean time, by applying the equation of time found in Table IV., A, or in the Nautical Almanac.*

The preceding examples I. and II. are thus worked by this method:—

EXAMPLE I.

	90° 0′		
☉'s cor. alt...	13 40		
Zen. distance	76 20		
Co-latitude ..	38 30	Cosecant	0.20585
Polar distance	96 40	Cosecant	0.00295
Sum	211 30		
Half-sum....	105 45	Sine....	9.98338
Zen. distance	76 20		
Remainder ..	29 25	Sine....	9.69122
		2)	19.88340

	90° 0′		90° 0′
Latitude...	51 30	☉'s dec. ..	6 40
Co-latitude	38 30	Polar dist..	96 40

Cosine.. 9.94170 corresponding to which in the column A. M is $8^h\ 7^m\ 46^s$, the apparent time of day, which agrees nearly with the other method.

* The correction for dip and semidiameter being 12′ additive, the correction for refraction is also to be applied as usual.

EXAMPLE II.

	90° 0′		
☉'s cor. alt..	15 54		
Zen. distance	74 6		
Co-latitude ..	50 6	Cosecant	0.11511
Polar distance	72 31	Cosecant	0.02054
Sum	196 43		
Half-sum....	98 22	Sine....	9.99535
Zen. distance	74 6		
Remainder ..	24 16	Sine....	9.61382
		2)	19.74482

	90° 0′		90° 0′
Latitude...	39 54	☉'s dec. ..	17 29
Co-latitude	50 6	Polar dist..	72 31

Cosine.. 9.87241 corresponding to which, in the column P. M., is $5^h\ 34^m\ 25^s$, the apparent time of day, which agrees nearly with the first method.

By the preceding method you may find the beginning or ending of the twilight, by calculating the hour when the sun's zenith distance is 108°, (or when the sun is 18° below the horizon ;) for by observation it has been found that the twilight begins or ends when the sun is at that distance from the zenith.

EXAMPLE III.

Required the time of beginning and ending of the twilight, in the latitude of 42° 23′ N., when the declination is 23° 27′ N.

Zenith distance	108° 0′		
Co-latitude	47 37	Cosecant...........	0.13156
Polar distance	66 33	Cosecant...........	0.03744
Sum...............	222 10		
Half-sum...........	111 5	Sine..	9.96991
Zenith distance.....	108 0		
Remainder	3 5	Sine...............	8.73069
		Sum...............	18.86960

Half-sum..... cosine 9.43480 which corresponds to $2^h\ 6^m\ 20^s$ A. M., and $9^h\ 53^m\ 40^s$ P. M. Therefore, the first appearance of the twilight in the morning was at $2^h\ 6^m\ 20^s$, and the end of it in the evening at $9^h\ 53^m\ 40^s$, apparent time.

THIRD METHOD.

If the sun's declination, and the latitude, be both north or both south, take their difference, but if one be north and the other south, take their sum, and from the natural cosine of this difference, or sum, subtract the natural sine of the true altitude, (both being found in Table XXIV.;) find the log. of their difference, (in Table XXVI. add thereto the log. secant of the latitude (from Table XXVII.) and the log. secant of the sun's declination, (from the same table,) rejecting 10 in each index; the sum of these three logarithms being found in the column of rising (Table XXIII.) the hours, minutes, and seconds, corresponding, will be the apparent time from noon; and by applying the equation of time to the apparent time, we get the mean time.

The preceding examples I. and II. are thus worked by this third method:—

Digitized by Google

EXAMPLE I.

Latitude......	51° 30′ N.			Secant..	0.20585
Declination ...	6 40 S.			Secant..	0.00295
Sum	58 10	Nat. cosine....	52745		
Sun's cor. alt..	13 40	Nat. sine......	23627		
		Difference	29118	Log.....	4.46416
					4.67296

corresponding to which in the column of rising. is....... $3^h\ 52^m\ 14^s$

	12
Subtracted from 12^h, leaves the apparent time.	8 7 46
Equation of time.......................sub.	12 56
Mean time of observation....................	7 54 50
Time per watch............................	8 21 00
Watch too fast per mean time................	26 10

agreeing nearly with the other methods.

EXAMPLE II.

Latitude......	39° 54′ N.			Secant..	0.11511
Declination ...	17 29 N.			Secant..	0.02054
Difference	22 25	Nat. cosine....	92444		
Cor. altitude ..	15 54	Nat. sine......	27396		
		Difference	65048	Log.....	4.81324
					4.94889

corresponding to which, in column rising, is apparent time $5^h\ 34^m\ 30^s$

Equation of time.........................sub.	3 49
Mean time of observation.....................	5 30 41
Time per watch............................	5 30 00
Watch too slow............................	41

agreeing nearly with the other methods. The differences between the results of the different methods arise chiefly from not taking notice of the seconds in the angles, and sometimes from not having the natural sines and cosines to 6 or 7 places of decimals; and we remark generally, that it is always best to retain the seconds in the calculation. This is easily done, in the first and second methods, by means of the columns A, B of proportional parts in Table XXVII.; and by retaining the seconds, we are sure to obtain a more correct result in the calculation.

Digitized by Google

TO FIND THE TIME AT SEA BY THE MOON'S ALTITUDE.

Having a chronometer which is pretty well regulated to Greenwich time, we can use the moon's altitude for finding the mean solar time at the ship, which is required in determining the longitude. For, in the present improved state of the Nautical Almanac, we can easily find the moon's right ascension and declination for that time at Greenwich, without the very troublesome operation of interpolating for the second and third differences, as was necessary in the former arrangement of that ephemeris. Even without a chronometer thus regulated, the time at Greenwich can be obtained, if we know the longitude of the ship, as well as the mean time at the place of observation, by a watch that will give it with a considerable degree of accuracy; because, by adding the longitude in time to the time by the watch, if the longitude be west, or subtracting it, if the longitude be east, we shall obtain the corresponding time at Greenwich. We must, however, always keep in mind, that the accuracy of an observation of this kind depends on the certainty with which the time at Greenwich is computed; because an error in this estimate affects the moon's right ascension and declination, which frequently vary rapidly, as may be seen by the inspection of the Nautical Almanac, where we shall find that in a minute of time the right ascension may vary more than 2^s, and the declination more than $15''$.

When we wish to ascertain the time by this method, we must observe, with a fore observation, the altitude of the moon's round limb, and at the same instant the time by the watch or chronometer, which is supposed to be regulated to Greenwich time. With this time at Greenwich we must take from the Nautical Almanac *the sun's right ascension, the moon's right ascension, the moon's declination, the moon's horizontal parallax, and the moon's semidiameter, to which we must add the augmentation from* Table XV. To the observed altitude we must apply the correction of the moon's semidiameter, by adding it, if the lower limb be observed, or subtracting it, if the upper limb be observed; from this sum or difference we must subtract the dip of the horizon, and we shall obtain the moon's central altitude. To this we must add the correction for parallax and refraction, and we shall obtain the moon's correct altitude, which is to be used in the rest of the calculation. This correction for parallax and refraction can easily be found, as in page 171, by means of Table XIX., by subtracting the tabular number, corresponding to the altitude and horizontal parallax, from $59' 42''$; the remainder will be the correction for parallax and refraction, to be used as above; and then we find the time by the following rule:—

RULE.

Add together the moon's *correct* altitude, the ship's latitude, and the polar distance; from the half-sum subtract the moon's correct altitude, and note the remainder; then add together the log. secant of the latitude, the log. cosecant of the polar distance, (rejecting 10 from each index,) the log. cosine of the half-sum, and the log. sine of the remainder; half the sum of these four logarithms will be the log. sine of half the hour angle; take out the corresponding time in the column marked P. M., in Table XXVII., and apply it to the moon's right ascension, by subtracting when the moon is east of the meridian, or adding when west of the meridian; the sum or difference will be the right ascension of the meridian. From the right ascension of the meridian (increased by 24 hours if necessary) subtract the sun's right ascension; the remainder will be the apparent time at the ship, and by applying to it the equation of time found in the Nautical Almanac, we shall get the required mean solar time at the meridian of the place of observation.

EXAMPLE.

When the mean time at Greenwich, by the chronometer, was, Nov. 29^d, 2^h 52^m astronomical account, the altitude of the moon's upper limb was observed, when

Digitized by Google

west of the meridian, and found to be 60° 25′ 8″, the latitude of the place 30° 20′ N., and the dip 4′. Required the mean time of observation.

We have from the Nautical Almanac, for the time, Nov. 29ᵈ 2ʰ 52ᵐ, the sun's right ascension, 16ʰ 22ᵐ 45ˢ; the moon's right ascension, 9ʰ 26ᵐ 23ˢ; the moon's declination, 20° 32′ 47″ N., or polar distance, 69° 27′ 13″; the moon's horizontal parallax, 54′ 29″; the moon's semidiameter, 14′ 49″ + Aug. Table XV. 14″ = 15′ 3″.

☽'s observed altitude, upper limb	60° 25′ 08″
☽'s semidiameter ......sub.	15 03
	60 10 05
Dip ......sub.	4 00
☽'s central altitude	60 06 05
Parallax and refraction = 59′ 42″ — Cor. Tab. XIX. 33′ 08″ ....add	26 34
☽'s correct altitude	60 32 39

☽'s correct altitude	60° 32′ 39″		
Latitude	30 20 00	Secant	0.06394
Polar distance	69 27 13	Cosecant	0.02854
Sum ......2)	160 19 52		
Half-sum	80 09 56	Cosine	9.23249
☽'s correct altitude	60 32 39		
Remainder	19 37 17	Sine	9.52608
		Sum ......2)	18.85105
		Half-sum... sine	9.42552

Corresponding to this, in the column P. M., is	2ʰ 03ᵐ 36ˢ
☽'s right ascension	9 26 23
Sum (being west of the merid.) gives right ascension of the meridian	11 29 59
Subtract the sun's right ascension	16 22 45
Gives the apparent time at the ship	19 07 14
Equation of time ......sub.	11 19
Mean time at the ship ......Nov. 28ᵈ.	18 55 55
Mean time at Greenwich by chronometer ......Nov. 29ᵈ.	02 52 00
Difference is the longitude by the chronometer	7 56 05 W

It very frequently happens, that, a few minutes before or after taking the sun's meridian altitude for the determination of the latitude, we can observe the moon's altitude for the regulation of the time; and as the latitude by observation is then known accurately, without depending on the ship's run for any considerable length of time, it will operate to render the regulation of the chronometer by the moon's altitude more accurate. In like manner, if we observe the latitude by the moon's meridian altitude, we can, at nearly the same time, take an observation of the sun's altitude to regulate the chronometer.

Digitized by Google

TO FIND THE TIME AT SEA BY A PLANET'S ALTITUDE.

We may use either of the large planets, Jupiter, Saturn, Mars, or Venus, for determining the time at sea; and the process is very nearly the same as that in the preceding section, where the moon's altitude is used. In this case, we must ascertain the time of observation, reduced to the meridian of Greenwich, either by a chronometer regulated to that meridian, or by knowing pretty nearly the mean time of observation at the ship, and the longitude; for by adding the longitude in time to th mean time at the ship by the watch, if the longitude be west, or subtracting the longitude if it be east, we shall obtain the corresponding time at Greenwich. With this time at Greenwich, we must take, from the Nautical Almanac, *the sun's right ascension, the planet's right ascension, the planet's declination, or polar distance.* The parallax and semidiameter might also be noticed, but the corrections from these quantities are so small that they may be neglected, as only amounting to a few seconds. Then from the observed central altitude of the planet we must subtract the dip and the refraction, and we shall obtain the planet's correct altitude.* With these we may find the time by the following rule:—

RULE.

Add together the planet's correct altitude, the ship's latitude, and the polar distance; from the half sum subtract the planet's correct altitude, and note the remainder; then add together the log. secant of the latitude, the log. cosecant of the polar distance, (rejecting 10 from each index,) the log. cosine of the half-sum, and the log. sine of the remainder; half the sum of these four logarithms will be the log. sine of half the hour angle; take out the corresponding time in the column marked P. M., Table XXVII., and apply it to the planet's right ascension, by subtracting from the right ascension when the planet is east of the meridian, or adding when west of the meridian; the sum or difference will be the right ascension of the meridian. From the right ascension of the meridian (increased by 24 hours if necessary) subtract the sun's right ascension; the remainder will be the apparent time at the ship; and by applying to it the equation of time, found in the Nautical Almanac, we shall get the required mean solar time, at the meridian of the place of observation.

EXAMPLE I.

In the latitude 42° 22′ N., and longitude 70° 15′ W., on May 26^d 7^h 18^m 35^s, astronomical time, by a watch which was very nearly regulated for mean time at the ship, observed the central altitude of the planet Jupiter, by a fore observation, and found it to be 32° 16′ 23″; the planet being to the west of the meridian, and the dip 4′ 8″ Required the mean time of observation at the ship.

Adding the longitude 4^h 41^m to the time by the watch, we get the mean time at Greenwich, May 26^d 11^h 59^m 35^s; and with this time we get, from the Nautical Almanac, the sun's right ascension 4^h 15^m 04^s; Jupiter's right ascension 7^h 8^m 32^s; Jupiter's declination 22° 48′ 39″ N., or polar distance 67° 11′ 21″.

* When very great accuracy is required, we may notice the parallax in altitude, which is found in Table X. A., and is to be added to the correct altitude computed by the above rule. We may also find the correction of refraction and parallax, by entering Table XVII. in the page corresponding to the horizontal parallax of the planet, and taking out the corresponding number, which, being subtracted from 60′, gives the correction for parallax and refraction, at one operation.

Digitized by Google

Observed altitude	32° 16′ 23″			
Dip 4′ 8″, ref. 1′ 30″..sub.	5 38			
Correct altitude.........	32 10 45			
Latitude	42 22 00	Secant	0.13145	
Polar distance...........	67 11 21	Cosecant	0.03537	
Sum ....2)	141 44 06			
Half-sum..............	70 52 03	Cosine	9.51555	
Altitude................	32 10 45			
Remainder	38 41 18	Sine....	9.79594	
		Sum.......... 2)	19.47831	
		Half-sum......sine	9.73916	

Corresponding to this, in the column P. M., is.....................	$4^h\ 26^m\ 06^s$
Planet's right ascension..	7 08 32
Sum (being west of meridian) gives right ascension of meridian......	11 34 38
Subtract the sun's right ascension..................................	4 15 04
Gives the apparent time at the ship.................................	7 19 34
Equation of time by Nautical Almanac.........................sub.	3 14
Mean time at the ship...	7 16 20

The time by the watch being $7^h\ 18^m\ 35^s$, it is 59^s too slow for apparent time and $2^m\ 15^s$ too fast for mean time.

EXAMPLE II.

January $5^d\ 15^h\ 40^m\ 24^s$, 1836, astronomical mean time, at a place in the latitude of 24° 16′ N., longitude 34° 56′ W. of Greenwich, observed the central altitude of the planet Saturn, by a fore observation, and found it to be 28° 15′; the planet being east of the meridian, and the dip 3′ 41″. Required the mean time of observation at the ship.

Adding the longitude $2^h\ 19^m\ 44^s$ to the time by the watch, we get the mean time at Greenwich, Jan. $5^d\ 18^h\ 00^m\ 08^s$; and with this time we get from the Nautical Almanac the sun's right ascension $19^h\ 5^m\ 13^s$; Saturn's right ascension $14^h\ 10^m\ 22^s$; Saturn's declination 10° 36′ 17″ S., or polar distance 100° 36′ 17″.

Observed altitude	28° 15′ 00″		
Dip 3′ 41″, ref. 1′ 46″, sub.	5 27		
Correct altitude........	28 09 33		
Latitude	24 16 00	Secant	0.04018
Polar distance	100 36 17	Cosecant	0.00749
Sum...............2)	153 01 50		
Half-sum...............	76 30 55	Cosine...........	9.36770
Altitude...............	28 09 33		
Remainder	48 21 22	Sine..............	9.87349
		Sum.......... 2)	19.28886
		Half-sum ..... sine	9.64443

Corresponding to this, in column P. M., is.........................	$3^h\ 29^m\ 20^s$
Saturn's right ascension	14 10 22
Difference (being east of meridian) gives right ascension of meridian..	10 41 02
Add 24^h, and subtract the sun's right ascension......................	19 05 13
Gives the apparent time at the ship	15 35 49
Equation of time by Nautical Almanac.........................add	5 46
Mean time at the ship...	15 41 35

The time by the watch being $15^h\ 40^m\ 24^s$, it was $4^m\ 35^s$ too fast for apparent time, and $1^m\ 11^s$ too slow for mean time.

Digitized by Google

TO FIND THE APPARENT TIME BY A STAR'S ALTITUDE.

Correct the observed altitude for the dip and refraction, (the dip being generally 4 minutes when the observation is taken on the deck of a common-sized vessel;) find the ship's latitude at the time of observation, and the star's right ascension and declination in Table VIII.* Add together the star's correct altitude, the ship's latitude, and the polar distance; from the half-sum subtract the star's altitude, and note the remainder. Then add together the log. secant of the latitude, the log. cosecant of the polar distance, (rejecting 10 in each index,) the log. cosine of the half-sum, and the log. sine of the remainder; half the sum of these four logarithms will be the log. sine of half the hour angle; take out the corresponding time in the column marked P. M. (Table XXVII.) and apply it to the star's right ascension, by subtracting when the star is east of the meridian, or adding when west of the meridian; the sum or difference will be the right ascension of the meridian. From the right ascension of the meridian (increased by 24 hours if necessary) subtract the sun's right ascension, taken from the Nautical Almanac;† the remainder will be the apparent time at the ship, and by applying to it the equation of time, we get the mean time at the ship.

EXAMPLE I.

Suppose that, on September $8^d\ 14^h\ 19^m\ 20^s$, 1836, astronomical time, as shown by a chronometer, regulated to mean time at Greenwich, when in the latitude of 7° 45′ S., and longitude of 29° 12′ E. from Greenwich, the altitude of the star Procyon, being then east of the meridian, was observed by a fore observation, and found to be 28° 16′, and the dip 4′. Required the mean time of observation at the ship.

By inspection in the Nautical Almanac, we find that, on the above-mentioned day Procyon's right ascension was $7^h\ 30^m\ 44^s$, and the declination 5° 39′ N., or polar distance 95° 39′ nearly, agreeing nearly with the result from Table VIII., corrected for the annual variations, &c.

Sun's right ascension by Nautical Almanac, Sept. 8, at mean noon...	$11^h\ 07^m\ 47^s$
Correction, Table XXXI., for $14^h\ 19^m\ 10^s$, mean time ....add	2 09
Sun's right ascension at the time of observation	11 09 56

Star's observed altitude......	28° 16′		
Dip 4′, ref. 2′, Table XII., sub.	6		
Star's correct altitude........	28 10		
Latitude....................	7 45	Secant...........	0.00399
Polar distance..............	95 39	Cosecant.........	0.00212
Sum.................. 2)	131 34		
Half-sum	65 47	Cosine...........	9.61298
Altitude	28 10		
Remainder	37 37	Sine.............	9.78560
		Sum .... 2)	19.40469
		Half-sum.........	9.70234

* The right ascensions and declinations of the stars in Table VIII. are the mean values for January 1st, 1830, and must be reduced to the time of observation by means of the annual variation given in the same table. When very great accuracy is required, the right ascensions and declinations, thus obtained, must be corrected for the aberration and nutation, as explained in the precepts of Tables XLII. XLIII; but in general these corrections may be neglected. These corrections are, however, all noticed in the places of 100 of the most noted fixed stars, given in the Nautical Almanac since the year 1834, for every ten days in the year; and when any of these stars are used, the places must be taken out, to the nearest day, from the Nautical Almanac, without any further correction, because the variations in ten days are very small. Thus, on July 29, 1836, Procyon's right ascension was $7^h\ 30^m\ 43^s$, *north* polar distance 84° 21′ 29″, or 5° 38′ 31″ N. declination, corresponding to 95° 38′ 41″ *south* polar distance. This additional table of the Nautical Almanac simplifies this kind of calculation considerably.

† The sun's right ascension and the equation of time are to be taken from the Nautical Almanac, for

Corresponding to this half-sum, in Table XXVII., in column P. M., is	$4^h\ 02^m\ 04^s$
Star's right ascension	7 30 44
Right ascension of the meridian	3 28 40
Increased by 24^h, it is	27 28 40
Subtract the sun's right ascension	11 09 56
Leaves the apparent time at the ship	16 18 44
Equation of time by the Nautical Almanac ..... sub.	2 43
Mean time at the ship	16 16 01

Now, the time by the chronometer being $14^h\ 19^m\ 20^s$, it was too slow for apparent time by $1^h\ 59^m\ 24^s$, or $1^h\ 56^m\ 41^s$ too slow for mean time.

We have, in this example, supposed the time at Greenwich to be given by the chronometer, which is the most simple way of proceeding; but if you have no chronometer, regulated to Greenwich time, you must, in the usual manner, estimate as nearly as you can the time at Greenwich, by adding the longitude, if west, to the time at the ship, or subtracting the longitude, if east; and then use this time in finding the numbers from the Nautical Almanac.

EXAMPLE II.

Suppose that, on April $16^d\ 12^h\ 13^m\ 03^s$, 1836, astronomical time, as shown by a chronometer, regulated to mean time at Greenwich, when in the latitude of 48° 57′ N., and longitude of 67° 25′ W., the altitude of Aldebaran, when west of the meridian, was 22° 25′, and the dip 4′. Required the apparent time at the ship.

In the Nautical Almanac, we find on that day that Aldebaran's right ascension was $4^h\ 26^m\ 30^s$, declination 16° 10′ N., or polar distance 73° 50′.

Sun's right ascension by Nautical Almanac, April 16^d, at mean noon	$1^h\ 38^m\ 20^s$
Cor. Table XXXI., for $12^h\ 13^m\ 03^s$	1 53
Sun's right ascension at the time of observation	1 40 13

Star's observed altitude	22° 25′		
Dip 4′, refraction 2′, Tab. XII.	6		
Star's correct altitude	22 19		
Latitude	48 57	Secant	0.18262
Polar distance	73 50	Cosecant	0.01752
Sum ..... 2)	145 06		
Half-sum	72 33	Cosine	9.47694
Altitude	22 19		
Remainder	50 14	Sine	9.88573
		Sum ..... 2)	19.56281
		Half-sum	9.78140

Corresponding to this half-sum, in Table XXVII., column P. M., is	$4^h\ 57^m\ 33^s$
Star's right ascension	4 26 30
Right ascension of the meridian	9 24 03
Subtract the sun's right ascension	1 40 13
Leaves the apparent time at the ship	7 43 50
Equation of time by the Nautical Almanac ..... sub.	25
Mean time at the ship	7 43 25

Now the time by the chronometer being $12^h\ 13^m\ 03^s$, it was too fast for apparent time $4^h\ 29^m\ 13^s$, or $4^h\ 29^m\ 38^s$ for mean time.

This method of obtaining the time by the stars would be accurate, if a good horizon could be obtained; but as that is not always the case, it is best to regulate your watch by the sun.

---

the time at Greenwich given by a chronometer, or by applying the longitude to the estimated time at the ship, in the usual manner.

Digitized by Google

TO REGULATE A CHRONOMETER BY EQUAL ALTITUDES OF THE SUN.

A CHRONOMETER may be regulated on shore by observing in the morning and evening the times when the sun is at the same altitude,* for the middle between these times would be the apparent time of noon by the chronometer. if the declination of the sun remained the same during the observation; but if the declination varies, as is generally the case, the apparent time of noon, determined in this manner, which, for distinction, we shall call the *middle time*,) must be corrected for the change of declination by an equation, called the *equation of equal altitudes*, and the middle time thus corrected will be the correct time of apparent noon by the chronometer. For greater accuracy, several altitudes should be taken in the morning, and corresponding ones in the afternoon, and the mean of the times of the morning and evening observations should be respectively taken, and the equation of equal altitudes, corresponding to the mean of all the observations, must be calculated and applied to the middle time, as if a single set of observations only had been taken.

In noting the times of observation, we must count the hours in numeral succession, so that if some of the observations are taken before 12^h by the chronometer, and others after 12^h, the next hour to 12^h must be called 13^h, the next 14^h, &c. Half the sum of the times of observation, corresponding to any set of observations, (or the mean of a number of observations,) will be the middle time, and the difference of the times of observation will be the elapsed time.

The equation of equal altitudes consists of two parts, which may be calculated by the following rule:—

RULE.

1. To the constant log. 8.8239 add the log. cotangent of the latitude, the log. sine corresponding to the elapsed time found in the column P. M. of Table XXVII., the proportional logarithm of the hours and minutes of the elapsed time, reckoned as minutes and seconds, and the proportional logarithm of the daily variation of the sun's declination; the sum (rejecting 30 in the index) will be the proportional logarithm of the first part of the equation of equal altitudes, reckoning minutes and seconds as seconds and thirds respectively.

2. To the constant log. 8.8239 add the log. cotangent of the sun's declination, the log. tangent corresponding to the elapsed time found in the column P. M. of Table XXVII., the proportional logarithm of the hours and minutes of the elapsed time reckoned as minutes and seconds, and the proportional logarithm of the daily variation of the sun's declination; the sum (rejecting 30 in the index) will be the proportional logarithm of the *second part* of the equation of equal altitudes, reckoning minutes and seconds as seconds and thirds respectively.

The first part of the equation of equal altitudes is to be added to the middle time when the sun is receding from the elevated pole, otherwise subtracted;† and the second part is to be added when the declination is increasing, but subtracted when decreasing;‡ these two corrections, being applied to the middle time, will give the apparent time of noon by the chronometer.

* The altitudes should be taken when the sun rises or falls fast. The best time for observation is when the bearing of the sun is nearly east or west, if the altitude exceed 8° or 10°, so as to avoid the irregular refraction near the horizon. In general, two or three hours from noon will be sufficient. An artificial horizon, formed by a vessel filled with mercury, may be used in taking these altitudes.

† Thus, in north latitudes, the first part is to be added from the summer to the winter solstice, when the polar distance is increasing, and subtracted the rest of the year, when the polar distance is decreasing.

‡ It is here supposed that the elapsed time is less than 12 hours, which is generally the case; but if that time exceeds 12 hours, the second part must be applied in a contrary manner to the above rule.

Digitized by Google

EXAMPLE.

Suppose that, on the 9th of May, 1836, civil account, in the latitude of 40° N., and longitude 10° W., the following observations were taken at equal altitudes of the sun; required the error of the watch.

Alt. ☉*'s lower limb.*		*Times per chron.* A. M.	*Times per chron.* P. M.
15° 35′		$6^h\ 29^m\ 51^s$	$17^h\ 32^m\ 18^s$
15 45		6 31 07	17 31 00
15 55		6 32 14	17 29 54
	Sum	93 12	93 12
	Mean	6 31 04	17 31 04
			6 31 04
	Difference is elapsed time		11 00 00
	Sum............................		2)24 02 08
	Middle time..........		12 01 04

Constant log...............	8.8239		8.8239
Latitude 40° ......cotangent	10.0762	Declination 17° 27′. cotangent	10.5026
Elapsed time 11^h.......sine	9.9963	Tangent	10.8806
Elapsed time 11^h, or 11′ P. L.	1.2139		1.2139
Variation declin. 15′ 46″* P.L.	1.0575		1.0575
1st part 12″ 14‴ P. L......	1.1678	2d part 0″ 36‴ P. L.	2.4785

The first part of this equation, 12″ 14‴, is subtractive, because the sun is proceeding towards the elevated pole; and the second part, 36‴, is additive, because the declination is increasing, so that the whole equation is about 12 seconds subtractive; this, being applied to the middle time, $12^h\ 1^m\ 4^s$, gives the time of apparent noon by the chronometer, $12^h\ 0^m\ 52^s$, so that the chronometer is 52 seconds too fast for apparent time.

* On May 9, at noon, by the Nautical Almanac, the declination was 17° 26′ 27″, and on the following noon 17° 42′ 13″, the difference 15′ 46″, being the daily variation; the declination corresponding to the longitude of 10° W., being 17° 27′ N. nearly.

Digitized by Google

TO REGULATE A CHRONOMETER BY MEANS OF A TRANSIT INSTRUMENT.

THIS method excels all others in brevity and accuracy; but it can only be used on shore, and with the transit instrument that has been adjusted with the greatest possible care, so as to have the motion of the line of collimation of the telescope perfectly in the plane of the meridian. We have already given, from pages 145 to 152, the methods of making these adjustments, and of observing these transits; we shall now insert several examples for illustration.

To determine the time by the sun's transit over the middle wire of the telescope.

In observations of this kind, we must note, by the chronometer, the times of the transit of the first and second limbs of the sun over the meridian wire; the mean of the two observations will be the time of apparent noon, by the chronometer. Then the equation of time is to be taken from the Nautical Almanac for the apparent noon at Greenwich, and the correction applied to it for the longitude of the place of observation, which is easily obtained by the means of the horary variation given in the same work. Applying this equation to the apparent time, by adding or subtracting, according to the directions in the Nautical Almanac, we get the mean time of apparent noon. The difference between this time and the time by the chronometer, will be the error of the chronometer in mean time; moreover the difference between the time by the chronometer and 12^h, will be the error of the chronometer for apparent time.

EXAMPLE I.

Near noon, at the commencement of the 29^d of January, 1836, according to the astronomical computation of time, in a place 30°, or 2^h, west of Greenwich, observed the transits of the limbs of the sun over the meridian wire of the transit instrument, for the purpose of regulating a chronometer. It is required to find, from these observations, the error of the chronometer, either for apparent or mean time.

Transit of the first limb by the chronometer....................	$11^h\ 56^m\ 10^s.5$
Transit of the second limb by the chronometer..................	11 58 27 .0
Sum .... 2)	14 37 .5
Half-sum is the time of apparent noon by the chronometer	11 57 18 .7
Equation of time by Nautical Almanac, at apparent noon, Greenwich	$13^m\ 21^s.63$
Correction for longitude, $2^h \times 0.432$ ....add	.86
Equation of time at the place of observation...................add	13 22 .5
Apparent time of observation at noon............................	12 00 00 .0
Mean time of observation	12 13 22 .5
Hence it appears, that the chronometer is too slow for apparent time	2 41 .3
Chronometer too slow for mean time..........................	16 03 .8

EXAMPLE II.

In another observation of the sun's transit, similar to the preceding, made June 25 1836, in the longitude of 60°, or 4^h, east, we shall suppose that the time of the

Digitized by Google

Transit of the first limb, by the chronometer, was................	12h 02m 10s.0
Transit of the second limb, by the chronometer...................	12 04 27 .8
Sum ....2)	6 37 .8
Half-sum is time of apparent noon by the chronometer	12 03 18 .9
Equation of time by Nautical Almanac at apparent noon at Greenwich	2m 14s.31
Correction for longitude, 4h × 0.529	2 .12
Equation of time at the place of observation..................add	2 12 .2
Apparent time of observation at noon	12 00 00 .0
Mean time of observation....................................	12 02 12 .2
Hence it appears, that the chronometer is too fast for apparent time	3m 18s.9
And too fast for mean time.................................	1 06 .7

To determine the time by the sun's transit, observed at the five wires of the telescope.

If the telescope of the transit instrument be furnished, as usual, with five equidistant and parallel wires, two on each side of the meridian wire, we can, with very little extra time or trouble, make the observations of the transits of the first limb of the sun at all the wires, and mark down the corresponding times by the chronometer, in five separate columns, on the same horizontal line, from left to right. Immediately afterwards,* make the observations of the transits of the second limb of the sun, over the same wires, and mark these times below the former numbers respectively, taking them in a contrary order, or from right to left. The sums of the two numbers in each of the five columns will be nearly the same,† and the mean of the whole will be the time of the transit of the sun's centre over the meridian, as shown by the chronometer. Comparing this with the time of apparent noon, 12h, we get the error of the chronometer for apparent time; or by comparing it with the mean time of noon, we get the error of the chronometer for mean time, as in the two preceding examples.

EXAMPLE III.

July 23, 1836, in the longitude of 74°, or 4h 56m, W., the following observations of the times of the transit of the sun's limbs over the wires of the transit instrument were made. Required the error of the chronometer for mean time.

	I.	II.	III.	IV.	V.
First limb......	5m 05s.0	5m 32s.0	12h 05m 59s.5	6m 27s.1	6m 54s.1
Second limb....	9 09 .3	8 42 .1	12 08 14 .3	7 47 .1	7 20 .2
Sum	14 14 .3	14 14 .1	24 14 13 .8	14 14 .2	14 14 .3
			14 .3		
			14 .1		
			14 .2		
			14 .3		
Sum			10)70 .7		
Mean of all is transit by chronometer.			12h 07m 07s.07		
Mean time of apparent noon........			12 06 07 .61		
Chronometer too fast for mean time..			0m 59s.46		
Chronometer too fast for apparent time			7m 07s.07		

Equation of Time.

Noon at Greenwich +	6m 07s.32
Corr. 4h 56m × 0.059	.29
Equation of time.	6 07 .61
	12h
	12 6 07 .61

* We have already remarked, in page 150, that the wires are so fixed in the telescope, that the first limb of the sun passes over all of them before the second limb arrives at the first wire.

† This equality in the sums renders it unnecessary to write down the hours of the observation, except in the middle column; and we may also neglect, in the column of minutes, the figures which stand for tens of minutes; retaining the full expression of the time only in the middle column.

Digitized by Google

EXAMPLE IV.

May 14, 1836, in the longitude of 45°, or 3^h, east, the following transits of the sun's limb over the wires of the transit instrument, were observed. Required the error of the chronometer for mean time.

	I.	II.	III.	IV.	V.
First limb......	$53^m\ 10^s.5$	$53^m\ 37^s.5$	$11^h\ 54^m\ 05^s.0$	$54^m\ 32^s.5$	$54^m\ 59^s.3$
Second limb....	57 14 .0	56 46 .5	11 56 19 .7	55 52 .1	55 25 .0
Sum	50 24 .5	50 24 .0	23 50 24 .7	50 24 .6	50 24 .3

	24 .5	
	24 .0	*Equation of Time.*
	24 .6	Noon at Greenwich —$3^m\ 56^s.30$
	24 .3	Corr. $3^h \times 0.014$.. .04
Sum	10) 122 .1	Equation of time — 3 56 .26
Mean of all the transits by chronometer	$11^h\ 55^m\ 12^s.21$	Apparent noon 12 00 00 .00
Mean time of apparent noon	11 56 03 .74	Mean noon .... 11 56 03 .74
Chronometer too slow for mean time.	$0^m\ 51^s.53$	
Chronometer too slow for app. time..	$4^m\ 47^s.79$	

To determine the time by the transit of a fixed star over the meridian.

In observations with the transit instrument, it is most commonly the case, that the chronometer which is used in making the observations, will give the *mean* time at Greenwich within a few seconds; * and for this time we must find, in the Nautical Almanac, the sun's right ascension and that of the star. Subtracting the former from the latter, (increased by 24^h when necessary,) we get the apparent time of the star's transit over the meridian; and by applying to it the equation of time, taken from the Nautical Almanac, for the above time at Greenwich, we obtain the mean time at the place of observation. The difference between this and the time of the transit, as noted by the chronometer, will represent its error. We may, as in observations of the sun, use the middle wire only, and note the time of the transit, when the star is bisected by that wire; or, with greater chance of accuracy, we may take the mean of the observed times of passing the five wires, as a more correct time of the actual transit. To illustrate this, we shall give the following examples :—

EXAMPLE V.

July 24, 1836, in the longitude of 44° 39′, or $2^h\ 58^m\ 36^s$, east, observed the transit of the star Arcturus over the middle wire of the telescope, the time by the chronometer which was supposed to be regulated very nearly for mean time in the meridian of Greenwich, being $3^h\ 00^m\ 10^s$. Required the mean time of the transit at the place of observation.

☉'s right ascension at noon, at Greenwich, by Nautical Almanac..		$8^h\ 15^m\ 05^s.79$
Correction for $3^h\ 00^m\ 10^s \times 9^s.891$..............................		29 .70
☉'s right ascension at the estimated time at Greenwich		8 15 35 .49
Star's right ascension at the same time, by Nautical Almanac......		14 08 12 .13
Subtract ☉'s right ascension, gives the apparent time of observation		5 52 36 .64
Equation of time at noon, Greenwich..........	$+6^m\ 08^s.74$	
Correction for $3^h\ 00^m\ 10^s \times 0^s.035$.............	.11	
Corrected equation of time..................	+6 08 .85......	+ 6 08 .85
Mean time of observation................		5 58 45 .49
Time by the chronometer......................................		3 00 10 .00
Error of the chronometer for mean time.......................		2 58 35 .49
Error of the chronometer for apparent time....................		2 52 26 .64

* When we have no good regulation of the chronometer, from Greenwich, we must estimate the time at that place, from the supposed time at the place of observation, by applying to it the longitude; adding when west, or subtracting when east; repeating the operation if we should find, after calculating the observations of the transit, that any essential error was made in the time at the place of observation.

Digitized by Google

EXAMPLE VI.

March 10, 1836, in the longitude of 17° 18′, or $1^h\ 09^m\ 12^s$, east, observed the transit of the star Sirius over the five wires of the telescope, at the times by the chronometer as given below; the chronometer being supposed to give very nearly the mean time at Greenwich. Required the mean time of this transit at the place of observation.

Time of transit by the chronometer.	First wire		$6^h\ 14^m\ 01^s.5$
	Second wire		14 28 .7
	Meridian wire		14 56 .0
	Fourth wire		15 23 .2
	Fifth wire		15 50 .6
	Sum		5)24 40 .0
Mean of all the times by the chronometer is			$6^h\ 14^m$ 56 .0
☉'s right ascension at noon, at Greenwich, by the Nautical Almanac			$23^h\ 23^m$ 10 .85
Correction for $6^h\ 14^m\ 56^s \times 9^s.186$			57 .40
☉'s right ascension at the estimated time at Greenwich			23 24 08 .25
Star's right ascension at the same time by the Naut. Almanac $+24^h$			30 37 55 .39
Subtract ☉'s right ascension, gives the apparent time of observation			7 13 47 .14
Equation of time for noon at Greenwich		$10^m\ 25^s.45$	
Correction for $6^h\ 14^m\ 56^s \times 0^s.668$		4 .17	
Corrected equation of time		10 21 .28.. .add	10 21 .28
Mean time of observation			7 24 08 .42
Time by the chronometer			6 14 56 .00
Error of the chronometer for mean time			1 09 12 .42
Error of the chronometer for apparent time			0 58 51 .14

We may in the same way find the time by a transit of the planet, either by taking the mean of the times of the transits of the two limbs of the planet across the middle wire, or the mean of the times of the limbs passing all the wires; then the calculation is to be made, as in Examples V. VI.; taking from the Nautical Almanac, and using the right ascension of the planet, instead of that of the star. This method is so plain, that it will not be necessary to give any examples. The transit of the moon might also be used; but the calculation becomes so complex, on account of the rapidity of her motion, that it is wholly inexpedient to use such observations for regulating a chronometer.

Digitized by Google

LUNAR OBSERVATIONS.

Almost all the methods of determining the difference of longitude between any two places, depend on the general principle of finding the difference between the times of taking any observation, estimated under the meridian of both those places. For. in any place, it is the time of apparent noon when the sun is on the meridian; and as the sun, by his diurnal motion, appears on the meridian of Greenwich (from which the longitude is reckoned) one hour earlier than in a place in 15° west longitude,* and one hour later than in a place in 15° east longitude, and in proportion for a greater or less longitude, it follows that, if, at the time of taking an observation, the corresponding time at Greenwich be known, the longitude of the place of observation will be found by allowing 15° for every hour of difference between those times, the longitude being east when the time at Greenwich is earlier than at the place of observation, otherwise west. It is immaterial whether the times at both places be estimated for *apparent* or *mean* time, as the interval is the same when both are apparent as when both are mean; it is, however, universally the practice, at present, to use mean time in all these calculations. Now, an observer, at any place, may determine the apparent or mean time at any moment, by a watch regulated by any of the preceding methods; and if, at the same moment, the apparent or mean time at Greenwich could be obtained, nothing more would be necessary for determining the longitude. One method of determining the time at Greenwich is by a watch regulated to Greenwich time; for it is evident that if a watch could be so constructed as to go uniformly at all times, and in all places, an observer, furnished with a watch thus regulated, would only have to compare the time at the place of observation with the time at Greenwich, shown by the watch, and the difference of the times would give the difference of longitude. This method is useful in a short run; but in a long voyage, implicit confidence cannot be placed in an instrument of such a delicate construction, and liable to so many accidents. Another method of determining the longitude, is by observing the beginning or end of an eclipse of the moon, or the satellites of Jupiter, and taking the difference between the mean time of observation and the mean time given in the Nautical Almanac for the meridian of Greenwich; it being evident that such an eclipse must be observed at both places at the same moment of absolute time; consequently the difference of the times will be the difference of longitude. An observation of an eclipse of the sun, or an occultation, after making allowance for parallax, &c., as taught in the Appendix to this work, may be used in like manner; and this is a very accurate method. However, observations of eclipses are but of small practical utility at sea; for those of the sun and moon happen too seldom, and the difficulty of observing the eclipses of Jupiter's satellites prevents that method from being made use of. In the present improved state of the Nautical Almanac, we may easily determine the longitude on shore, by means of a transit instrument, by observing the time of the moon's transit over the meridian, or by observing the difference between the time of the moon's transit and that of some well-known and near star. Other methods of finding the longitude at sea have been proposed, but among them all there is not one of such practical utility, as that by measuring the angular distance of the moon from the sun, or from certain fixed stars situated near the ecliptic, usually called a *lunar observation*, or, more frequently, "*a lunar.*" For observations of this kind may be taken, in fair weather, at all times (except near the time of new moon) when the objects are more than 8° or 10° above the horizon; and as the moon moves in her orbit about 1′ in 2^m of time, it follows that, if her angular distance can be ascertained from the sun or star within 1′, the time at Greenwich will be known within 2 minutes, and the longitude within 30 miles.

* Because the sun, by his apparent diurnal motion, describes 360 degrees in 24 hours, which makes 15 degrees in an hour.

Digitized by Google

To facilitate this method, there is annually published, by the Bureau of Navigation, of the United States, a Nautical Almanac, containing the true angular distances of the moon from the sun, from the four large planets, and from nine bright fixed stars, for the beginning of every third hour of mean time for the meridian of Greenwich; and the mean time corresponding to any intermediate hour may be found by proportional parts: hence, an observation of these angular distances being taken in any place, and the corresponding mean time at Greenwich being found by the Almanac, and compared with the mean time at the ship, their difference will be the longitude of the place of observation. But before the observed angular distance is compared with those in the Nautical Almanac, the corrections for parallax and refraction must be applied to obtain the *true distance;* for, the moon being seen always lower than her true place, and the sun and stars higher, the true distance is almost always greater or less than the observed distance.

The angular distances of the moon from the sun and proper fixed stars and planets, are generally given in the Nautical Almanac from one object on each side of her, to afford a greater number of opportunities of observation, and to enable the observer to correct, in a great degree, the errors of the instrument, the adjustments, or a faulty habit of observing the contact of the limbs, because these errors have a natural tendency to correct each other, in taking the mean of observations made with objects on different sides of the moon. Before taking the observation, the Nautical Almanac must be examined, to see from what objects the distances are computed, and from them only must the distances be measured.

There are only nine fixed stars and four planets from which the angular distances are computed in the Nautical Almanac; and as it is of the greatest importance to be able to discover them easily we shall here add a number of remarks which will be found useful for that purpose.

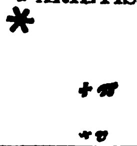
The best way of discovering any star or planet, is by means of a celestial globe; observing that, when a planet is used, we must estimate roughly, by inspecting the Nautical Almanac, the right ascension and declination of the planet, and make a mark on the corresponding point of the globe with a pencil, or by attaching a small piece of moist paper, and this must be considered as the place of the planet. If a globe cannot be obtained, the time of passing the meridian, and the meridian altitude of the object, may be calculated; and by observing at that time, the object may be easily discovered. The distances marked in the Nautical Almanac afford also to the observer an easy method of knowing the star or planet from which the moon's distance is to be observed; for he has nothing to do but to set the sextant or circle to the distance computed roughly for the apparent time, estimated nearly for the meridian of Greenwich, and direct his sight to the east or west of the moon, according as the object is marked E. or W. in the Nautical Almanac; and, having found the reflected image of the moon upon the horizon glass, sweep the instrument to the right or left, and the image will pass over the sought star or planet, if above the horizon, and the weather clear: the star or planet is always one of the brightest, and is situated nearly in the arc passing through the moon's centre, perpendicular to the line connecting the two horns.

The computed distance made use of in sweeping for the star, may be found in this manner:—Reckon the apparent time at the ship in the manner of astronomers, (by counting 24 hours from noon to noon, and taking the day one less than the sea account;) to this time apply the longitude turned into time, by adding in west, or subtracting in east longitude; the sum or difference will be the apparent time at Greenwich nearly. Take the distances from the Nautical Almanac for the time immediately preceding and following this estimated time, and note the difference of these distances; then say, As 3^h, or 180^m, is to the difference of the distances, so is the difference between the apparent time at Greenwich and the next preceding time, set down in the Nautical Almanac, to a proportional part to be added to the next preceding distance taken from the Nautical Almanac, if the distance be increasing, but subtracted if decreasing; the sum or difference will be the distance at which the quadrant or sextant is to be fixed.

In sweeping for the stars by this method, it will often happen that two or more are swept upon at once; this might cause some difficulty to an inexperienced observer who would be at a loss to know which to make use of. To remove this, the following description of these stars is added:—

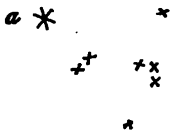
Digitized by Google

α ARIETIS.



This star bears about west, distant 23°, from the Pleiades, or the Seven Stars; it is of the second magnitude, and may be known by means of the star π, of the third magnitude, situated S. W. from α Arietis, at the distance of 3¾ degrees. South from the star π, at the distance of 1½°, is the star ν, of the fourth magnitude. The northernmost of these stars is α Arietis.

ALDEBARAN.

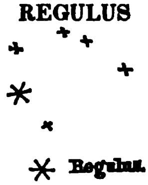


About 35° E. S. E. from α Arietis, and 14° S E. from the Pleiades, or Seven Stars, is the bright star Aldebaran. Near this star, to the westward, are six or seven stars of the third or fourth magnitude, forming, with Aldebaran, a figure resembling the letter V, as is represented in the adjoined figure, where Aldebaran is marked α. At the distance of 23° from this star, in a S. E. direction, are three very bright stars, situated in a straight line, near to each other, forming the belt of Orion.

POLLUX.

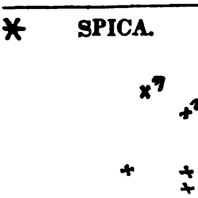
At the distance of 45° from Aldebaran, in the direction of E. N. E., is the star Pollux, which is a bright star, though not of the first magnitude. N. W. from it, distant 5°, is the star Castor, of nearly the same magnitude; and you will almost always sweep both at once: the southernmost is the one used.

REGULUS



E. by S. ½ S. from Pollux, at the distance of 37½°, is the star Regulus, of the first magnitude; to the northward of this star (at the distance of 8°) is a star of the second magnitude; near to these are five stars of the third magnitude, the whole forming a cluster resembling a sickle, represented in the adjoined figure, Regulus being in the extremity of the handle. A line drawn from the northern polar star, through its pointers, passes about 12° to the eastward of Regulus.

SPICA.

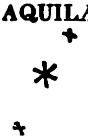


E. S. E. from Regulus, at the distance of 54°, is the star Spica, of the first magnitude, with no very bright star near it; S. W from this star, at the distance of about 16°, are five stars of the third or fourth magnitude, situated as in the adjoined figure; the two northernmost of these stars, η, ν, form a straight line with Spica, and by this mark it may be easily discovered. A line drawn from the northern polar star, through the middle star of the tail of the Great Bear, will pass near to Spica.

ANTARES.

E. S. E. from Spica, at the distance of 46°, is the star Antares, in 26° of south declination; it is a remarkable star, of a reddish color; on each side of it, to the W. N. W. and S. S. E., about 2° distant, is a star of the third or fourth magnitude, no very bright star being near.

α AQUILÆ.

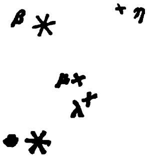


N. E. from Antares, at the distance of 60°, is the very bright star α Aquilæ; N. N. W. from which, at 2° distance, is a star of the third magnitude, and, S. S. E., at 3° distance, another star of a less magnitude. These three stars appear nearly in a straight line. The star α Aquilæ is nearly of the same color as Antares.

FOMALHAUT.

S. E. from α Aquilæ, at the distance of 60°, is the star Fomalhaut, which is a bright star of high southern declination its altitude in northern latitudes being small, never exceeding 20° in the latitude of 40° N. This star bears nearly south from the star α Pegasi, distant 45°. A line drawn from the pointers, through the northern polar star, and continued to the opposite meridian, will pass very near to α Pegasi and Fomalhaut.

α PEGASI.



E. by N. from α Aquilæ, at the distance of 48°, and westward from α Arietis, at the distance of 44°, is the star α Pegasi, which may be known by means of four stars of different magnitudes, situated as in the adjoined figure; in which α represents α Pegasi, β a star of the second magnitude, bearing north of it, distant 13°. the others are of less magnitudes, and two of them, η, μ, form a straight line with the star α Pegasi; and by this mark it may be easily discovered

Digitized by Google

General Remarks on the taking of a Lunar Observation.

The accuracy of a lunar observation depends chiefly on the regulation of the chronometer, and on the exact measurement of the angular distance of the moon from the sun or star; a small error in the observed altitudes of those objects, will not in general much affect the result of the calculation.

The best method of regulating a chronometer at sea, is by taking an altitude of the sun when rising or falling quickly, or when bearing nearly east or west, the altitude being sufficiently great to avoid the irregular refraction near the horizon, and noting the time by the chronometer. With this altitude, the latitude of the place, and the sun's declination, find the mean time of observation by either of the preceding methods; the difference between this time and that shown by the chronometer will show how much it is too fast or slow. A single observation, taken with care, will generally be exact enough; but if greater accuracy is required, the mean of a number of observations may be taken. If the distance of the sun and moon be observed when the sun is three or four points distant from the meridian, the mean time of observation may be deduced from the altitude of the sun taken at the precise time of measuring the distance; this will render the use of a chronometer unnecessary, and will prevent any irregularity* in its going from affecting the result of the observation. If a night observation is to be taken, the chronometer should be regulated by an altitude of the sun taken the preceding evening, and its going examined by means of another observation taken the next morning; for the time found by an altitude of a star cannot be so well depended upon, except in the morning and evening twilight, as the horizon is generally ill-defined; but the altitude may be sufficiently exact for finding the correction used in determining the angular distance.

Although all the instruments used in these observations ought to be well adjusted, yet particular care should be taken of the sextant or circle used in measuring the angular distance of the moon from the sun or star, since an error of 1′ in this distance will cause an error of nearly 30′ in the longitude deduced therefrom. When a great angular distance is to be measured, it is absolutely necessary to use a telescope, and the parallelism of it, with respect to the plane of the instrument, must be carefully examined; but in measuring small distances, the use of the telescope is not of such great importance, and a sight-tube may then be used, taking care, however, that the eye and point of contact of the objects on the horizon-glass be equally distant from the plane of the instrument. But it ought to be observed, that it is always conducive to accuracy to use a telescope, and, after a little practice, it is easily done.

Whilst one person is observing the distance of the objects, two others ought to be observing the altitudes. The chronometer should be placed near one of the observers, or put into the hands of a fourth person appointed to note the time; the observer who takes the angular distance giving previous notice to the others to be ready with their altitudes by the time he has finished his observation; which being done, the time, altitudes, and distance,† should be carefully noted, and other sets of observations taken, which must be done within the space of 15 minutes, and the mean of all these observations must be taken and worked as a single one.

When a ship is close-hauled to the wind, with a large sea, or when sailing before the wind, and rolling considerably, it is difficult to measure the distance of the objects; but when the wind is enough upon the quarter to keep the ship steady, there is no difficulty, especially in small distances, which are much more easily measured than large ones, and are not so liable to error from an ill adjustment of the telescope: an observer would therefore do well to choose those times for observation when the distance of the objects is less than 70° or 80°. An observation of the sun and moon is generally much easier to take when the altitude of the moon is less than that of the sun, because the instrument will be held in a more natural and easy manner When the moon is near the zenith, the observation is generally difficult to take, and liable to be erroneous, because the observer is forced to place himself in a disagreeable posture. For the same reason, an observation of the moon and a star or planet

---

* It is not uncommon to find a difference in the regulation of a chronometer in the forenoon and afternoon; this difference generally arises from the uncertainty in the estimated latitude, or some slight error in the observation, and perhaps partly from the irregularity in the going of the chronometer.

† If the distances are measured by a circular instrument, it will not be necessary to note the several distances measured, but only the times and altitudes, as the sum of all the distances measured by the circle will be given by the instrument at the end of the observations; and if the altitudes of the objects are also measured by circular instruments, it will not be necessary to note the several altitudes, but only the times of observation

Digitized by Google

is generally much easier to take when the star or planet is lower than the moon. This situation of the objects may in most cases be obtained by taking the observation at a proper time of the day. But it must be observed, that neither of the objects, if possible, ought to be at a less altitude than 10°, upon account of the uncertainty of the refraction near the horizon; for the horizontal refraction varies from 33′ to 36′ 40″ only by an alteration of 40° in the thermometer. This alteration might cause an error of two degrees in the longitude, with an observer who uses the mean refraction.

In measuring the distance of the moon from the sun, we must bring the moon's round limb in contact with the nearest limb of the sun. In measuring the distance of the moon from a planet or fixed star, her round limb must be brought in contact with the centre of the star or planet; observing that, the semidiameter of the planet being only a few seconds, the centre of it can be estimated sufficiently near for all the purposes of this observation.*

In taking the altitude of the moon, the round limb, whether it be the upper or lower, must be brought to the horizon. In damp weather, it is rather difficult to observe the altitude of the stars, on account of their dimness, particularly α Pegasi and α Arietis. Sometimes they are so dim that they cannot be seen through the holes of the sight-vane of a quadrant, particularly if the mirrors are not well silvered; in this case, the vane must be turned aside, and the eye held in nearly the same place, or the altitude must be taken by a sextant furnished with a sight-tube.

We have here supposed that there were observers enough to measure the altitudes when the distance was observed; but if that is not the case, the altitudes may be estimated by either of the methods which will be hereafter given.

Preparations necessary for working a Lunar Observation

Find the mean time of observation by astronomical account, reckoning the hours from noon to noon in numerical succession from 1 to 24, and taking the day one less than the sea account; to this time apply the longitude turned into time by Table XXI.† by adding if in west longitude, but subtracting if in east; the sum or difference ‡ will be the supposed time at Greenwich, or *reduced time.*

In page III. of the month of the Nautical Almanac, find the moon's semidiameter and horizontal parallax, for the nearest noon and midnight before and after the reduced time, and find the difference of the parallaxes and the difference of the semidiameters; then enter Table XI. with these differences respectively in the side column, and the reduced time at the top; opposite the former, and under the latter, will stand the corrections § to be applied respectively to the semidiameter and horizontal parallax marked first in the Nautical Almanac, additive if increasing, subtractive if decreasing; the sum or difference will be the horizontal semidiameter and the *horizontal parallax*, respectively, at the time of observation. To this horizontal semidiameter must be added the augmentation from Table XV. corresponding to the moon's altitude; the sum will be the *true semidiameter* of the moon.

The sun's true semidiameter is to be found in page II. of the month of the Nautical Almanac.

To the observed altitude of the sun's or moon's lower limb add 12′; but if the upper limbs were observed, subtract 20′, and from the observed altitude of the star or planet subtract 4′, and you will have nearly the *apparent altitudes* of those objects respectively.‖

---

* If any one wishes to proceed with perfect accuracy, he may bring the round limb of the moon to the nearest limb of the planet, and then apply the planet's semidiameter, taken from the Nautical Almanac, in the same manner as in observations of the sun.

† Or by multiplying by 4 sexagesimally, in the manner directed in the note page 170.

‡ When the sum exceeds 24 hours, you must subtract 24 hours, and add one to the day of the month; and when the time to be subtracted is greater than the mean time, the latter must be increased by 24 hours, and one day taken from the day of the month, conformably to the usual rules of addition and subtraction. If the chronometer used in taking the observation be regulated to Greenwich time, this part of the calculation will be unnecessary, because the reduced time at Greenwich will be given directly by the chronometer.

§ These corrections may be found easily without the table, by saying, As 12 hours are to the reduced time, (rejecting 12 hours when it exceeds 12,) so is the difference of semidiameter or parallax for 12 hours to the corresponding correction. If the reduced time cannot be found accurately in the table, you must use the nearest numbers, which will, in general, be sufficiently accurate.

‖ These altitudes are supposed to be taken at sea by a fore observation; and the application of the above numbers will give the apparent altitudes corresponding to observations taken on the deck of a common-sized vessel (where the dip is about 4′ or 5′) to a sufficient degree of accuracy; if the observer was 40 or 50 feet above the water, 1′ or 2′ might be taken from these altitudes. The propriety of using these numbers will appear by considering that every wave, by raising the ship above the level of the sea, will alter the dip, and that an error of 1′ or 2′ in the altitudes will in general cause but a

Digitized by Google

To the *observed distance of the moon from a star or planet* add the moon's true semidiameter, if her nearest limb was observed, but subtract that semidiameter if her farthest limb was observed; the sum or difference will be the *apparent distance*. But to the *observed distance of the sun and moon's nearest limbs*, add their true semidiameters; the sum will be the *apparent distance*.

These preparations are necessary in every method of working a lunar observation The most noted methods are those of Dunthorne, Borda, Maskelyne, Rios, Witchell, Lyons, &c., and improvements thereon by various authors.

Dunthorne's and similar methods have one great advantage in not being liable to a variety of cases; but these methods are tedious, when tables of logarithms to minutes only are used, by reason of the great exactness required in proportioning the logarithms to seconds. This is obviated in the excellent methods published by Rios and Stansbury; but they require large and expensive tables, and on that account are not in very general use. Witchell's and Lyons's methods do not labor under the inconvenience of requiring large tables, nor do they require any particular notice of the seconds in finding the log. sines and log. tangents; but these methods, as they were originally published, are embarrassed with a variety of cases; sometimes the corrections are additive, sometimes subtractive; and learners find a difficulty in rightly applying them. To remedy this, a method was published in the first edition of this work, in which two corrections were constantly additive, two subtractive, and one small correction was additive when the distance was less than 90°, but subtractive when above 90°. This method was further improved in the Appendix to that edition, by means of four new tables, which are inserted in this edition, and numbered XVII. XVIII. XIX. and XX., by means of which the work is considerably shortened, and all the corrections rendered additive. This method will now be given, after making a few remarks on the manner of taking the corrections and logarithms from these new tables.

Table XVII. contains a correction and logarithm to be used when the moon's distance from a star or planet is observed; and Table XVIII. is a similar one, to be used when the moon's distance from the sun is observed. Table XVII. contains six pages, corresponding to the horizontal parallax of the planet, supposing it to be either 0″, 5″, 10″, 15″, 20″, 25″, or 30″, as at the top of the pages respectively; and tha page is to be used which agrees the nearest with the horizontal parallax of the plane at the time of observation.* These tables are so extended, that no proportional parts are necessary in taking out the corrections and logarithms, except the altitude of the sun or star be less than 7° 30′, and at such altitudes an observation is liable to error on account of the uncertainty of the refraction; so that, in using these tables, it is sufficiently accurate to find the number nearest to the given altitude of the sun or star, and make use of the corresponding correction and logarithm. Thus, if the star's altitude be 12° 25′, the nearest number in Table XVII. is 12° 24′, corresponding to which are the correction 55′ 45″, and the logarithm 1.3161.

Table XIX. contains the corrections and logarithms corresponding to the moon's horizontal parallax and altitude, both being found at the same opening of the book. The corrections for seconds of parallax and minutes of altitude are easily taken out by means of Tables A, B, C, placed in the margin. The method of finding these corrections is given at the bottom of the table: they are always additive.

Besides the two logarithms taken from Table XVII. (or XVIII.) and XIX., this new rule requires only four logarithms to be taken from Table XXVII. to four places of figures, and to the nearest minute, it being in general unnecessary to proportion for the seconds.

We shall now give the rule for correcting the distance, and shall, for brevity, use the words *sine*, *secant*, and *cosecant*, instead of *log. sine*, *log. secant*, and *log. cosecant*, respectively, and the same practice will be observed in the second, third, and fourth methods of correcting the distance.

---

small error in the result of the calculation of a lunar observation, so that for all practical purposes the above numbers may be esteemed as sufficiently exact. It may also be observed, that the error arising from this source will not generally be greater than that arising from neglecting the equations depending on the spheroidal form of the earth, and on the density and temperature of the air; equations which are almost always neglected.

If any one wishes to obtain the apparent altitudes strictly, he must, from the observed altitudes subtract the dip of the horizon taken from Table XIII., and add or subtract the semidiameter of the object, according as the lower or upper limb is observed.

* In strictness, when the horizontal parallax differs from those in the table, we ought to take the numbers for the next greater and the next less number, and take a proportional part of the differences but this degree of accuracy is wholly unnecessary in nautical observations.

Digitized by Google

FIRST METHOD

Of correcting the apparent distance of the moon from the sun, in which there is no variety of cases, all the corrections being additive.*

Add the apparent distance of the moon from the sun to their apparent altitudes, and note the *half-sum.* The difference between the half-sum and the apparent distance call the *first remainder;* and the difference between the half-sum and the sun's apparent altitude call the *second remainder.*

Take from Table XXVII. the following logarithms, which mark beneath each other in two columns, viz. the sine of the apparent distance, to be marked in both columns, the cosecant of the second remainder, to be marked also in both columns, the secant of the first remainder to be placed in the first column, and the secant of the half-sum in the second column.†

Enter Table XVIII. (or Table XVII. if a star or planet be used), and take out the correction corresponding to the sun's altitude (or star or planet's); take also from the same table the corresponding logarithm, which place in column 1st.

Enter Table XIX. with the moon's apparent altitude and horizontal parallax; find the corresponding correction, which place under the former correction, and the logarithm, which place in column 2d.

The sum of the four logarithms † of column first will be the proportional logarithm of the first correction, and the sum of the logarithms of column second † will be the proportional logarithm of the second correction; these corrections being found in Table XXII. are to be placed under the former corrections.

Enter Table XX., and find the numbers which most nearly agree with the observed distance and the observed altitudes of the objects and take out the corresponding correction in seconds, which is to be placed under those already found. Then, by adding all these corrections to the apparent distance, decreased by 2°, we shall get the true distance nearly.‡

To determine the longitude from the true distance.

If the true distance of the objects can be found in the Nautical Almanac, in either of the pages where the distances are marked, on the day of the observation, the time will be found at the top of the page. If the true distance cannot be found exactly, in the Nautical Almanac, you must find the two which are nearest to it, the one greater and the other less than the true distance; and take out that one which corresponds with the earliest or first of these times, with the corresponding proportional logarithm. Find the difference between this first distance and the true distance, and take out its proportional logarithm from Table XXII. The difference between these two proportional logarithms will be the proportional logarithm of a portion of time, to be added to the time standing over the first distance in the Nautical Almanac, and the sum will be the mean time of the observation at Greenwich. The difference between this time and the mean time at the ship, being turned into degrees and minutes by Table XXI., will be the true longitude of the ship from Greenwich, at the time of observation. This longitude will be east if the time at the ship be greater than that at Greenwich, otherwise west.§

To exemplify the preceding rules, we shall now give several examples of correcting the apparent distance, including also the preparation and the determination of the longitude from the true distance.

---

* This rule is the same as that for correcting the distance of the moon from a star or a planet, except in reading *star* or *planet* for *sun*, and using Table XVII. instead of Table XVIII.

† Rejecting always the tens in the indices.

‡ The distance obtained by this rule is not perfectly correct, since several small corrections must be applied to obtain the true distance to the nearest second, viz. (1) The refraction taken from Table XII. which is made use of in constructing Tables XVII. XVIII. and XIX., ought to be corrected for the different heights of the barometer and thermometer, as directed in page 154. (2) A correction must be applied for the spheroidal figure of the earth. And (3) a very small correction ought to be made in the numbers of Table XX. when the ☽'s horizontal parallax varies from 57′ 30″. But to notice all these corrections would increase the calculation very much, and the result of a single observation, in which all these things were noticed, would probably not be so accurate as the mean of two or three observations, taken at different times of the day, in which these corrections were neglected; and the time necessary to take and work the latter observations would not be much greater than to work a single observation, in which all the corrections were noticed.

§ It may be necessary to observe that, if the times at the ship and Greenwich fall on different days the latest day is to be reckoned the greatest, though the hour of the day may be the least; thus, 17th day . hour is to be esteemed greater than 16th day 22 hours

Digitized by Google

EXAMPLE I.

Suppose that, on the 7th of January, 1836, sea account, at 11^m 57^s past midnight, mean time, in the longitude of 127° 30′ E., by account, the observed distance of the farthest limb of the moon from the star Aldebaran, was 68° 36′ 00″, the observed altitude of the star 32° 14′, and the observed altitude of the moon's lower limb 34° 43′ Required the true longitude.

Preparation.

Sea account, Jan. 7, is by N. A. Jan.	6^d 12^h 11^m 57^s
Longitude 127° 30′ E.	8 30 00
Reduced time .... Jan.	6^d 3^h 41^m 57^s

☽ semidiam. Jan. 6, noon	15′ 05″
midnight	15 09
Difference	4
Table XI.	1
	15 06
Aug. Table XV........	9
☽ semidiameter	15′ 15″

☽ hor. par. Jan. 6, noon..	55′ 20″
midnight	55 34
Difference..............	14
Table XI...............	4
☽ hor. par.............	55′ 24″

✱ observed alt....	32° 14
Subtract.........	4
✱ apparent alt....	32 10
☽ obs. alt. L. L. .	34° 43
Add	12
☽ apparent alt. ..	34° 55

Observed distance ✱ ☽ F. L.		68° 36′ 00″
☽ semidiameter	subtract	15 15
Apparent distance ✱ ☽		68° 20′ 45″

To find the true distance.

App. dist.	68° 21′
✱ app. alt.	32 10
☽ app. alt.	34 55
Sum....	135 26
Half-sum	67 43
App. dist.	68 21
1 Rem. ..	0 38
Half-sum	67 43
✱ app. alt.	32 10
Rem....	35 33

Col. 1.		Col. 2.	
Sine	9.9682	Same	9.9682
2 Rem. 35° 33′. Cosec.	0.2355	Same	0.2355
1 Rem. 0 38. Sec...	0.0000	Half-sum 67° 43′. Sec.	0.4212
Table XVII. ..Log. .	1.7018	Table XIX.†....Log.	0.2238
1 Corr 2′ 14″ P. L....	1.9055	2 Corr. 25′ 30″ P. L. .	0.8487

App. dist. less 2° =	66° 20′ 45″
Table XVII.......	58 29
Table XIX.*......	15 37
1 Corr.	2 14
2 Corr.	25 30
Table XX.........	25
True distance.....	68° 03′ 00″

To find the longitude.

True distance	68° 03′ 00″		
Distance by N. A. at 3^h	67 41 43	.... Prop. log.	2872
Difference	0 21 17	.... Prop. log.......	9272
	0^h 41^m 14^s	.... Prop. log. diff...	6400
Add	3		
Mean time at Greenwich	3 41 14		
Mean time at the ship	12 11 57		
Difference is longitude in time.....	8 30 43	= 127° 40′ 45″ E. from Greenwich.	

* This corr. = Corr. Tab. XIX. 15′ 05″ + Corr. Tab. A. 29″ + Corr. Tab. B. 3″ = 15′ 37″.
† This log. = Log. Tab. XIX. 2231 + Log. Tab. C. 7 = 2238.

Digitized by Google

EXAMPLE II.

Suppose, 1836, April 2d 2h 03m 50s A. M., mean time, sea account, in the longitude of 172° E., by account, the observed distance of the moon's farthest limb from Antares, was 61° 04′ 00″, the observed altitude of the star 68° 29′, the observed altitude of the moon's lower limb 45° 23′. Required the true longitude.

Preparation.

Sea account, April 2, or by N. A., April	1d 14h 03m 50s
Longitude 172° E.	11 28 00
Reduced time ... April	1d 02h 35m 50s

☽ semidiam. April 1. noon	15′ 59″	☽ horizontal par. noon	58′ 38″	✱ observed alt.	68° 29
midnight	16 4	midnight	58 56	Subtract	4
Difference	5	Difference	18	✱ apparent alt.	68° 25
Table XI.	1	Table XI.	4		
Sum	16 00	☽ horizontal parallax	58′ 42″	☽ obs. alt. L. L.	45° 23
Aug. Table XV.	11			Add	12
☽ semidiameter	16′ 11″			☽ apparent alt.	45° 35

Observed distance ✱ ☽ F. L.	61° 04′ 00″
Subtract ☽ semidiameter	16 11
Apparent distance ✱ ☽	60° 47′ 49″

To find the true distance.

		Col. 1.		Col. 2.		
App. dist.	60° 48′	Sine	9.9410	Same	9.9410	App. dist. less 2° = 58° 47′ 49″
✱ app. alt.	68 25	2d Rem. 18° 59′. Cosec.	0.4877	Same	0.4877	Table XVII. 59 37
☽ app. alt.	45 35	1st Rem. 26 36 ... Sec.	0.0486	Half-sum 87° 24′. Sec.	1.3433	Table XIX.* 19 32
Sum	174 48	Table XVII. ... Log.	1.9438	Table XIX.† ... Log.	0.1954	1st Corr. 0 41
Half-sum	87 24	1st Corr 0′ 41″. P. L.	2.4211	2d Corr. 1′ 56″ .. P. L.	1.9674	2d Corr. 1 56
1st Rem.	26 36					Table XX. 19
2d Rem.	18 59					True distance ... 60° 09′ 54

To find the true longitude.

True distance	60° 09′ 54″		
Distance by N. A. at 0h	61 40 13	Prop. log.	2348
Difference	1 30 19	Prop. log.	2995
	2h 35m 06s	Prop. log. diff.	0647
Add	0 00 00		
Mean time at Greenwich	2 35 06		
Mean time at the ship	14 03 50		
Difference is longitude in time	11 28 44 = 172° 11′ E. from Greenwich.		

* This corr. = Corr. Tab. XIX. 19′ 17″ + Corr. Tab. A. 12″ + Corr. Tab. B. 3″ = 19′ 32″

† This log. = Log. Tab. XIX. 1945 + Log. Tab. C. 9 = 1954

Digitized by Google

EXAMPLE III.

Suppose that, on the 30th of Oct. 1836, sea account, in the forenoon, in the longitude of 80° W., by account, the following observations of the sun and moon were taken; the times being noted by a chronometer which was 3ᵐ 47ˢ too slow for mean time at the place of observation. Required the true longitude.

Preparation.

Time per Watch.	*Observed Distance* ☉ ☾ *N. L.*	*Observed Altitude* ☉ *L. L.*	*Observed Altitude* ☽ *L. L.*
H. M. S.	° ′ ″	° ′	° ′
9 38 01	111 35 49	24 47	26 17
9 39 04	35 18	24 51	21
9 40 06	34 47	24 55	25
9 41 00	34 20	24 59	29
9 41 49	33 56	25 03	33
5) 200 00	174 10	124 35	125
9 40 00	111 34 50	24 55	26 25
Error + 3 47	☽ S. D. 14 53	Add 12	Add..... 12
Mean time 9 43 47	☉ S. D. 16 09	☉ App. alt. 25 07	☽ App. alt. 26 37
	App. dist. 112 05 52		

Sea account, 30th October, or N. A., October 29ᵈ 21ʰ 43ᵐ 47ˢ or 9ʰ 43ᵐ 47ˢ A. M.
Longitude 80° W.......................... 5 20 00

Reduced time......................October 30ᵈ 3ʰ 03ᵐ 47ˢ

☽ semidiameter, Oct. 30, noon....	14′ 46″
midnight	14 46
Difference	0
Table XI.	0
Sum...........................	14 46
Aug. Table XV.	7
☽ semidiameter	14′ 53″

☽ horizon. par. Oct. 30, noon....	54′ 10
midnignt	54 10
Difference....................	0
Table XI.	0
☽ horizontal parallax	54′ 10

To find the true distance.

		Col. 1.	Col. 2.	
App. dist. 112° 06′	Sine 9.9669	Same 9.9669	App. dist. less 2° = 110° 05′ 52″
☉ app. alt. 25 07	2d Rem. 56° 48′. Cosec. 0.0774	Same 0.0774	Table XVIII...... 58 06
☽ app. alt. 26 37	1st Rem. 30 11 ...Sec. 0.0633	Half-sum 81° 55′. Sec. 0.8520	Table XIX.*...... 13 10
Sum 163 50	Table XVIII....Log. 1.6336	Table XIX.†.... Log. 0.2376	1st Corr........... 3 16
Half-sum 81 55	1st Corr. 3′ 16″..P. L. 1.7412	2d Corr. 13′ 14″. P.L. 1.1339	2d Corr............ 13 14
1st Rem.. 30 11			Table XX. 15
2d Rem... 56 48			True distance .... 111° 33′ 53″

To find the true longitude.

True distance..................... 111° 33′ 53″
Distance by N. A. at 0ʰ........... 112 54 10 .... Prop. log..... 3468

Difference .... 1 20 17 .... Prop. log..... 3506

2ʰ 58ᵐ 01ˢ .... Prop. log. diff. 0048

Add 0

Mean time at Greenwich....Oct. 30ᵈ 02ʰ 58ᵐ 01ˢ
Mean time at the ship.......Oct. 29 21 43 47

Difference is longitude in time..... 5 14 14 = 78° 38′ 30″ W. from Greenwich.

---

* This corr. = Corr. Tab. XIX. 12′ 23″ + Corr. Tab. A. 44″ + Corr. Tab. B. 3″ = 13′ 10″.
† This log. = Log. Tab. XIX. 2364 + Log. Tab. C. 12 = 2376

Digitized by Google

EXAMPLE IV.

Suppose that, on the 12th of May, 1836, sea account, at about 1ʰ P. M., in the latitude of 30° S., and in the longitude of 4° 00′ E., by account, the following observations of the sun and moon were taken; the sun being so situated that the apparent time could be observed by her altitude. Required the true longitude.

Preparation.

Observed Distance ☉ ☾ *N. L.*		*Observed Altitude* ☉ *L. L.*		*Observed Altitude* ☽ *U. L.*	
	° ′ ″		° ′		° ′
	46 07 09		39 59		28 32
	06 01		45		28 07
	04 56		31		27 42
	3) 18 06		135		84 21
Mean..........	46 06 02		39 45		28 07
Index errors....	—03		—2		+01
Corrected dist...	46 05 59		39 43		28 08
☉ semidiameter.	15 51	Add	12	Subtract..	20
☽ semidiameter.	15 25	☉ app. alt.	39 55	☽ app. alt.	27 48
Apparent dist...	46 37 15				

Sea account, May 12, or N. A., May 11ᵈ	1ʰ 0ᵐ 00ˢ	
Longitude 4° 00′ E................	16 00	
Reduced time ....May	11ᵈ 0ʰ 44ᵐ 00ˢ	

☽ semidiameter, May 11, noon ...	15′ 17″	☽ horizontal parallax, noon	56′ 04″
midnight	15 13	midnight ...	55 49
Difference	4	Difference......................	15
Table XI.	0	Table XI.........................	1
	15 17	☽ horizontal parallax............	56′ 03″
Aug. Table XV.................	8		
☽ semidiameter..................	15′ 25″		

To find the true distance.

		Col. 1.		Col. 2.			
App. dist.	46° 37′	Sine..................	9.8614	Same	9.8614	App. dist. less 2° =	44° 37′ 15″
☉ app. alt.	39 55	2d Rem. 17° 15′. Cosec.	0.5279	Same	0.5279	Table XVIII.....	58 59
☽ app. alt.	27 48	1st Rem. 10 33 ...Sec.	0.0074	Half-sum 57° 10′. Sec.	0.2658	Table XIX.*.....	11 54
Sum	114 20	Table XVIII....Log.	1.8307	Table XIX.†....Log.	0.2215	1st Corr..........	1 04
Half-sum	57 10	1st Corr. 1′ 4″.. P. L.	2.2274	2d Corr. 23′ 55″. P. L.	0.8766	2d Corr.	23 55
1st Rem..	10 33					Table XX........	34
2d Rem...	17 15					True distance....	46° 13′ 41″

To find the mean time and the true longitude.

☉ correct altitude	39° 54′			True distance	46° 13′ 41″	
Latitude of ship..	30 00	... Secant..	10.06247	By N. A. at 0ʰ	46 34 02	.. Prop. log. 3097
Polar distance...	107 58	... Cosecant	10.02171	Difference	20 21	.. Prop. log. 9467
Sum	177 52			Difference	0° 41′ 32″	.. Prop. log. 6370
Half-sum	88 56	... Cosine..	8.26988	Add	0	
Half-sum — alt.	49 02	... Sine....	9.87800	Mean time at Green.	0 41 32	
		Sum....	18.23206	Mean time at ship..	0 56 09	
Apparent time..	1ʰ 0ᵐ 3ˢ	... Sine....	9.11603	Longitude in time..	14 37 = 3° 39′ 15″ E. from Greenwich	
Eq. of time . sub.	3 54					
Mean time	0 56 09					

* This corr. = Corr. Tab. XIX. 11′ 02″ + Corr. Tab. A. 49″ + Corr. Tab. B. 3″ = 11′ 54″.
† This log = Log. Tab. XIX. 2207 + Log. Tab. C. 8 = 2215.

Digitized by Google

EXAMPLE V.

Suppose that, on the 13th of February, 1836, sea account, at 8h 36m 00s, mean time, A. M., in the longitude of 16° W. from Greenwich, by account, six distances of the sun and moon's nearest limbs were observed, by a circle of reflection, to be 273° 09′ 06″, the corresponding times and altitudes being as in the following table. Required the true longitude.

Preparation.

Mean Time per Watch, A. M.	*Observed Distance ☉ ☾ N. L.*	*Observed Altitude ☉ L. L.*	*Observed Altitude ☽ U. L.*
H. M. S.		° ′	° ′
8 33 24	Sum of the dis-	27 42	42 24
34 36	tances taken from	27 54	42 42
35 18	the circle at the	28 02	42 51
36 36	end of the obser-	28 12	43 01
37 04	vations.	28 21	43 11
39 02		28 44	43 21
Sums 6) 36 00	273° 9′ 06″	55	17 30
Mean time } 8 36 00	45 31 31	28 09	42 55
	☉ S. D. 16 13	Add..... 12	Subtract.. 20
	☽ S. D. 16 29	☉ app. alt. 28 21	☽ app. alt. 42 35
	App. dist. 46 04 13		

February 13, sea account, or by N. A., February 12d 20h 36m 00s
Longitude 16° W. 1 04 00
Reduced time .... February 12d 21h 40m 00s

☽ semidiameter, Feb. 12, midnight 16′ 17″
Feb. 13, noon ... 16 18
Difference 1
Table XI 1
16 18
Aug. Table XV 11
☽ semidiameter .... 16′ 29″

☽ hor. parallax, Feb. 12, midnight 59′ 46″
Feb. 13, noon ... 59 47
Difference 1
Table XI 1
☽ horizontal parallax .... 59′ 47″

To find the true distance.

		Col. 1.	Col. 2.	
App dist.	46° 04′	Sine 9.8574	Same 9.8574	App. dist. less 2° = 44° 04′ 13″
☉ app. alt.	28 21	2d Rem. 30° 09′ Cosec. 0.2991	Same 0.2991	Table XVIII 58 22
☽ app. alt.	42 35	1st Rem. 12 26 .. Sec. 0.0103	Half-sum 58° 30′ Sec. 0.2819	Table XIX.* 16 41
Sum	117 00	Table XVIII. .. Log. 1.6874	Table XIX.† ... Log. 0.1878	1st Corr. 2 31
Half-sum	58 30	1st Corr. 2′ 31″. P. L. 1.8542	2d Corr. 42′ 34″. P. L. 0.6262	2d Corr. 42 34
1st Rem.	12 26			Table XX 34
2d Rem.	30 09			True distance ..... 46° 04′ 55″

To find the true longitude.

True distance .... 46° 04′ 55″
Distance by N. A., Feb. 12d 21h .... 46 28 04 .... Prop. log..... 2551
Difference .... 23 09 .... Prop. log..... 8907
0h 41m 39s .... Prop. log. diff. 6356
Add 21
Mean time at Greenwich 21 41 39
Mean time at the ship 20 36 00
Difference is longitude in time ...... 1 05 39 = 16° 24′ 45″ W. from Greenwich.

* This corr. = Corr. Tab. XIX. 16′ 29″ + Corr. Tab. A. 9″ + Corr. Tab. B. 3″ = 16′ 41″.
This log. = Log. Tab. XIX. 1875 + Log. Tab. C. 3 = 1878.

Digitized by Google

EXAMPLE VI.

Suppose that, on the 21st of June, 1836, sea account, at 6h 50m 40s P. M., mean time, in the longitude of 61° W., by account, the observed distance of the *nearest limb* of the moon *from the centre* of the planet Venus, was 35° 59′ 57″, the observed altitude of the planet 23° 00′, and the observed altitude of the moon's lower limb 37° 31′ Required the true longitude.

Preparation.

Sea account, June 21st, is by N. A.	June 20d	6h 50m 40s
Longitude 61° W. in time..................		4 04 00
Reduced time..........................	June	20d 10h 54m 40s

☽ semidiam. June 20, noon	15′ 10″	☽ hor. par June 20, noon	55′ 38″	♀ observed alt.	23° 00′
midnight	15 15	midnight	55 59	Subtract	4
Difference	5	Difference	21	♀ apparent alt.....	22° 56′
Table XI.	5	Table XI.	19		
Sum	15 15	☽ horizontal parallax	55′ 57″	☽ obs. alt. L. L....	37° 31
Aug. Table XV..........	10			Add	12
☽ semidiameter	15′ 25″			☽ apparent alt.....	37° 43

Observed distance ☽ ♀ N. L.		35° 59′ 57″
☽ semidiameter	add	15 25
Apparent distance ☽ ♀		36° 15′ 22″

To find the true distance

		Col. 1.		Col. 2.		
App. dist. 36° 15′	Sine	9.7718	Same	9.7718	App. dist. less 2° = 34° 15′ 22″	
♀ app. alt. 22 56	2d Rem. 25° 31′. Cosec.	0.3658	Same	0.3658	Table XVII.*.....	58 05
☽ app. alt. 37 43	1st Rem. 12 12 ... Sec.	0.0099	Half-sum 48° 27′. Sec.	0.1783	Table XIX........	16 40
Sum..... 96 54	Table XVII. .. Log.*	1.6348	Table XIX. .....Log.	0.2185	1st Corr............	2 52
Half-sum 48 27	1st Corr. 2′ 58″..P. L.	1.7823	2d Corr. 52′ 35″. P L.	0.5344	2d Corr.............	52 35
1st Rem.. 12 12					Table XX.........	41
2d Rem.. 25 31					True distance.....	36° 26′ 21″

To find the true longitude.

True distance......................	36° 26′ 21″		
Distance by N. A. at 9h............	35 28 17	.... Prop. log.....	2985
Difference	0 58 04	.... Prop. log.....	4913
	1h 55m 28s	.... Prop. log. diff.	1928
Add	9		
Mean time at Greenwich	10 55 28		
Mean time at the ship	6 50 40		
Difference is longitude in time......	4 04 48	= 61° 12′ W. from Greenwich	

---

* The horizontal parallax of Venus being 20″ by the Nautical Almanac, we must, in finding from Table XVII. the correction and logarithm, use that table which is marked at the top, "Parallax 20" being the 93d page.

Digitized by Google

EXAMPLE VII.

Suppose that, on the 27th of August, 1836, sea account, at $0^h\ 50^m\ 08^s$ A. M., mean time, in the longitude 25° W., by account, the observed distance of the *farthest limb* of the moon *from the centre* of the planet Mars, was 114° 05′ 17″, the observed altitude of the planet 10° 30′, and the observed altitude of the moon's upper limb 22° 51 Required the true longitude

Preparation.

Sea account, August 27. is by N. A.	August	$26^d\ 12^h\ 50^m\ 08^s$
Longitude 25° W. in time..................		1 40 00
Reduced time.....................	August	$26^d\ 14^h\ 30^m\ 08^s$

☽ semidiam. Aug. 26, mid.	16′ 10″	☽ hor. par. Aug. 26, mid.	59′ 20	♂ observed alt.....	10° 30
Aug. 27, noon	16 5	Aug. 27, noon	59 00	Subtract..........	4
Difference..............	5	Difference............	20	♂ apparent alt. ...	10° 26
Table XI...............	1	Table XI.	4		
	16 9	☽ horizontal parallax..	59′ 16″	☽ observed alt. U.L.	22° 51
Aug. Table XV.	6			Subtract..........	20
☽ semidiameter.........	16′ 15″			☽ apparent alt.....	22° 31

Observed distance ♂ ☽ F. L......................		114° 05′ 17″
☽ semidiameter..........................	subtract	16 15
Apparent distance ♂ ☽		113° 49′ 02″

To find the true distance.

		Col. 1.		Col. 2.		
App. dist. 113° 49′	Sine	9.9614	Same	9.9614	App. dist. less 2° =	111° 49′ 02″
♂ app. alt. 10 26	2d Rem. 62° 57′. Cosec.	0.0503	Same	0.0503	Table XVII *....	55 03
☽ app. alt. 22 31	1st Rem. 40 26 ... Sec.	0,1185	Half-sum 73° 23′. Sec.	0.5437	Table XIX.	7 12
Sum 146 46	Table XVII.... Log.*	1.2525	Table XIX. .... Log.	0.1998	1st Corr...........	7 27
Half-sum. 73 23	1st Corr. 7′ 27″.. P. L.	1.3827	2d Corr. 31′ 38″. P.L.	0.7552	2d Corr............	31 38
1st Rem.. 40 26					Table XX.	14
2d Rem... 62 57					True distance	113° 30′ 36″

To find the true longitude.

True distance....................	113° 30′ 36″		
Distance by N. A. at 12^h..........	114 55 06	.... Prop. log.....	2455
Difference	1 24 30	.... Prop. log.....	3284
	$2^h\ 28^m\ 44^s$	.... Prop. log. diff.	0829
Add	12		
Mean time at Greenwich...........	14 28 44		
Mean time at the ship..............	12 50 08		
Difference in longitude in time	1 38 36	= 24° 39′ W. from Greenwich.	

* The horizontal parallax of Mars being 4″.98, by the Nautical Almanac, we may find the correction and logarithm in Table XVII., page 90, corresponding to the nearest parallax 5″.

Digitized by Google

SECOND METHOD

*Of finding the true distance of the moon from a star.**

This method is grounded on that which was first published by Mr. Lyons, and afterwards improved by various persons by the introduction of tables similar to Tables XLVII., XLVIII., of the present collection. In Lyons's method there are four principal corrections, and several small ones, like those which are included in Table XX.; the first and second of these corrections depend on the refraction; the third and fourth, on the moon's parallax. These two last corrections correspond very nearly to the first and second of the present improved method. The first and second corrections of Lyons's method, with all the smaller corrections, are given very nearly by means of Table XLVIII., under the name of the third correction of the present method; the numbers in this table are liable to an error of a few seconds in consequence of using the moon's mean horizontal parallax in computing the numbers. Several of the quantities in each page of the table have been compared by means of Shepard's tables with the correct results, for the extreme values of the moon's horizontal parallax; and it has been found that an error exceeding 5″ will rarely occur in computing the distance from the numbers in the table, if the process of interpolation be carefully attended to, when the proposed distance and the altitudes are not expressly given in the table, as most commonly happens.

When this tabular form was first adopted in finding this third correction, the intervals were much longer than they now are, and the table contained only one page; the process of interpolation was then difficult, and liable to a considerable degree of inaccuracy, sometimes amounting to more than half a minute. This source of error has been successively diminished by increasing the number of pages in the table; and it was finally published by Mr. Thompson, in nearly the same form as in Table XLVIII. of the present collection, which is so extended that we can, without much error, neglect wholly the process of interpolation, and take out, by mere inspection, the tabular correction for the nearest degrees in the table corresponding to the distance and altitudes. Thus, if the apparent distance be 29° 10′, the moon's apparent altitude 21° 15′, and the star's apparent altitude 18° 25′, we must enter the table in page 278, corresponding to the apparent distance 28°, moon's altitude 21°, star's altitude 18°, and take out the corresponding correction 1′ 19″; which differs but very little from the true value, found by interpolation.

This second method has not the same advantage as the first method, of being wholly free from cases, for the second correction is found at the *top* of Table XLVII. when the distance is greater than 90°, and at the *bottom* when less than 90°; moreover the effect of the parallax of the sun, or that of a planet, is sometimes *additive*, and at other times *subtractive*. In this, as well as in the third and fourth methods, the preparation is the same as in the first method; and the process of finding the longitude from the true distance is also the same: it will therefore be unnecessary to repeat the rules for these calculations, which we have given in pages 229, 231 and we shall restrict ourselves to the explanation of the process for computing the true distance, which is done in the following manner:—

RULE.

To the proportional logarithm of the moon's horizontal parallax, (Table XXII.) add the log. cosecant of the star's apparent altitude, (Table XXVII.) the log. sine of the star's apparent distance, (Table XXVII.;) the sum (rejecting the tens in the indices) will be a logarithm which is to be found in Table XLVII.; and the corresponding number of degrees, minutes, and seconds, taken at the top of the page, is the *first correction.*

To the proportional logarithm of the moon's horizontal parallax, (Table XXII.) add the log. cosecant of the moon's apparent altitude,* (Table XXVII.) and the log. tangent of the apparent distance, (Table XXVII.;) the sum (rejecting the tens in the indices) will be a logarithm which is to be found in Table XLVII.; and the corresponding *second correction* is to be found at the top of the table, if the apparent distance exceed 90°; but the *second correction* is to be found at the bottom of the table, if the apparent distance be less than 90°.

* The same rule may be used for the sun or a planet, correcting for the parallax by means of Tables XLIX. and L., as will be shown hereafter.

Digitized by Google

Take the *third correction*, by inspection, from Table XLVIII., for the nearest degrees corresponding to the apparent distances and altitudes.

Add these three corrections to the apparent distance; the sum, decreased by 10° gives the *true distance of the moon from the star.*

When the sun is used, instead of a star, we must take out the correction for the sun's parallax, in the part P, of the same page of Table XLVIII. in which the third correction is found; and this correction is to be applied, by *addition* or *subtraction*, according to its sign in the table, to the true distance above computed, as for a star.

When a planet is used, we can find the correction of the distance for the planet's parallax, by means of Tables XLIX., L. The first of these tables, being entered with the nearest degrees of the distance and altitudes, gives the correction, with its sign, supposing the horizontal parallax to be 100″. This is reduced to the actual parallax by means of Table L. We may also find this correction very nearly by the table marked P, on the same page of Table XLVIII. where the third correction is found; which gives the correction of the distance, with its sign, supposing the horizontal parallax to be equal to the sun's mean parallax, 8″.6; if the horizontal parallax of the planet be greater or less than 8″.6, this correction must be increased or decreased in the same proportion, always retaining the same sign. The correction thus found is to be applied to the true distance, above computed for a star.

EXAMPLE VIII.

[Being the same as EXAMPLE III., page 234.]

Suppose that, on October 30, 1836, sea account, in the forenoon, in the longitude of 80° W., by account, at $9^h\ 43^m\ 47^s$, mean time, the observed distance of the nearest limb of the sun and moon was 111° 34′ 50″, the altitude of the sun's lower limb 24° 55′, and the altitude of the moon's lower limb 26° 25′. Required the true longitude.

The preparation is the same as in page 234, which, for want of room on this page, we shall not repeat, but merely give the results, namely:—Apparent distance 112° 05′ 52″; ☉'s apparent altitude 25° 07′; ☽'s apparent altitude 26° 37′; ☽'s semi-diameter 14′ 53″; ☽'s horizontal parallax 54′ 10″.

To find the true distance.

☽ hor. par....	0° 54′ 10″	......Prop. log.	0.5215	Same.............................. 0.5215
☉ app. alt....	25 07 00	.......Cosec....	10.3722	☽ apparent altitude 26° 37′.....Cosec... 10.3487
App. dist....	112 05 52	.......Sine	9.9669	.... Tangent 10.3914
1st Corr....	4 35 11	..Tab. XLVII. Log.	0.8606	2d Corr. Tab. XLVII. ....Log. ... 1.2616
2d Corr.....	4 50 09			
3d Corr.....	2 45			
Sum—10°=	111 33 57			
☉ par. Tab. P.	—6			
	111 33 51	= True distance, differing 2″ from the first method in page 234.		

To find the true longitude.

True distance......................	111° 33′ 51″		
Distance by N. A. at 0^h............	112 54 10	.... Prop. log.....	3458
Difference	1 20 19	.... Prop. log.....	3505
	$2^h\ 58^m\ 03^s$	.... Prop. log. diff.	0047
Add	0		
Mean time at Greenwich....Oct. 30^d	$2^h\ 58^m\ 03^s$		
Mean time at the ship.......Oct. 29	21 43 47		
Difference is longitude in time.....	5 14 16	= 78° 34′ W. from Greenwich.	

Digitized by Google

EXAMPLE IX.

[Same as EXAMPLE I., page 232.]

Suppose that, on the 7th of January, 1836, sea account, at 11m 57s mean time, past midnight, in the longitude of 127° 30′ E., by account, the observed distance of the farthest limb of the moon from the star Aldebaran, was 68° 36′ 00″, the observed altitude of the star 32° 14′, and the observed altitude of the moon's lower limb 34° 43′. Required the true longitude.

Preparation.

Sea account, Jan. 7, is by N. A. Jan.	6d	12h	11m	57s
Longitude 127° 30′ E.		8	30	00
Reduced time .... Jan.	6d	3h	41m	57s

☽ semidiam. Jan. 6, noon	15′ 05″	☽ hor. par. Jan. 6, noon..	55′ 20″	✱ observed alt....	32° 14
midnight	15 09	midnight	55 34	Subtract.........	4
Difference	4	Difference..............	14	✱ apparent alt....	32 10
Table XI.	1	Table XI...............	4		
	15 06	☽ horizontal parallax....	55′ 24″	☽ obs. alt. L. L. .	34° 43′
Aug. Table XV........	9			Add	12
☽ semidiameter	15′ 15″			☽ apparent alt. ..	34° 55′

Observed distance ✱ ☽ F. L.	68° 36′ 00″
☽ semidiameter ....subtract	15 15
Apparent distance ✱ ☽	68° 20′ 45″

To find the true distance.

☽ hor. par.......	0° 55′ 24″	........Prop. log. 0.5118	Same	0.5118
✱ app. alt.......	32 10 00	............Cosec. 0.2738	☽ apparent altitude 34° 55′..Cosec.	0.2423
App. dist........	68 20 45	.............Sine 9.9682	......................Tangent	0.4012
1st Corr.........	4 28 16	..Tab. XLVII. Log. 0.7538	2d Corr. Tab. XLVII ....Log.	1.1553
2d Corr..........	5 12 35			
3dCorr.Tab.XLVIII.	1 25			

Sum — 10° = 68° 03′ 01″ = True distance, differing 1″ from the first method, in page 232.

To find the longitude.

True distance	68° 03′ 01″		
Distance by N. A. at 3h	67 41 43	.... Prop. log. ...	2872
Difference	0 21 18	.... Prop. log.....	9269
	0h 41m 16s	.... Prop. log. diff.	6397
Add	3		
Mean time at Greenwich	3 41 16		
Mean time at the ship	12 11 57		
Difference is longitude in time.....	8 30 41	= 127° 40′ 15″ E. from Greenwich.	

THIRD METHOD

Of finding the true distance of the moon from the sun, a planet, or a star

RULE.

From the sun's refraction (Table XII.) take his parallax in altitude, (Table XIV.;) the remainder call the *correction of the sun's altitude.* In like manner, if a planet be used, we must find the planet's refraction, (in Table XII.) and subtract from it the parallax in altitude, (Table X. A.;) the remainder will be the *correction of the planet's altitude.* But if a star be used, we must find the refraction, (Table XII.) and that will be the *correction of the star's altitude.**

From the proportional logarithm of the moon's horizontal parallax, (increasing the index by 10,) take the sine of the moon's apparent zenith distance, (Table XXVII.; the remainder will be the prop. log. of the parallax in altitude, which must be found in Table XXII., and the moon's refraction (Table XII.) subtracted therefrom; the remainder will be the correction of the moon's altitude.†

Add together the apparent distance of the sun and moon, (planet and moon, or star and moon,) and their apparent zenith distances, (or complement of their apparent altitudes,) and note the *half-sum* of these numbers; the difference between the half-sum and the moon's apparent zenith distance call the *first remainder;* and the difference between the half-sum and the sun's (planet or star's) apparent zenith distance, call the *second remainder.*

To the constant log. 9.6990 add the cosecant of the half-sum, and the sine of the apparent distance, (both taken from Table XXVII.;) the sum (rejecting 20 from the index) will be a *reserved logarithm.*

To the reserved logarithm add the sine of the sun's (planet or star's) apparent zenith distance, the cosecant of the first remainder, (both taken from Table XXVII.) and the prop. log. of the correction of the sun's (planet or star's) altitude, (Table XXII.;) the sum (rejecting 30 from the index) will be the prop. log. of the *first correction,* to be found in Table XXII.

To the reserved logarithm add the sine of the moon's apparent zenith distance,‡ the cosecant of the second remainder, (Table XXVII.) and the prop. log. of the correction of the moon's altitude, (Table XXII.;) the sum (rejecting 30 from the index) will be the prop. log. of the *second correction,* to be found in Table XXII.

Then, to the apparent distance add the correction of the moon's altitude, and the first correction, and subtract the sum of the second correction and the correction of the sun's (planet or star's) altitude; the remainder will be the corrected distance.

Enter Table XX., and find the numbers which most nearly agree with the observed distance, and the observed altitudes of the objects, and take out the corresponding correction in seconds, which is to be added to the corrected distance, and then 18″ subtracted from the sum; the remainder will be the true distance.‡

We shall now give an example of this third method of correcting the distance; but it will be unnecessary to repeat the preparation and the process to find the longitude, as it is very nearly the same as in page 232.

EXAMPLE X.

[Same as Example I., preceding.]

Suppose the apparent distance of the centre of the moon from the star Aldebaran was 68° 20′ 45″, the apparent altitude of the star 32° 10′, the apparent altitude of the

---

* We may also find this correction by means of Table XVII., or Table XVIII.; taking the difference between the tabular number and 60′ for the correction; using Table XVIII. for the sun, and Table XVII. for a planet, or a fixed star.

† This correction may very easily be found by means of Table XIX., by subtracting the tabular number from 59′ 42″; for the remainder will be the correction of the moon's altitude for parallax and refraction.

‡ Neglecting the small corrections mentioned in a note marked ‡, in page 231.

Digitized by Google

moon's centre 34° 55′, and the moon's horizontal parallax 55′ 24″. Required the true distance of the moon from the star.

	90° 00′		90° 00′	Hor. par. 55′ 24″ ....P. L.	10.5118		
☽ app. alt....	34 55	✱ app. alt....	32 10	☽ zenith dist. 55° 05′....Sine	9.9138	✱ refraction	1′ 31″
☽ zenith dist.	55 05	✱ zenith dist.	57 50	45′ 26″...P. L.	0.5960		
				☽ refraction	1 21		
				Corr. ☽ altitude	44 05		

App. dist......	68° 21′	Constant log.	9.6990		
☽ zenith dist.	55 05	Half-sum 90° 38′.......Cosec.	10.0000		
✱ zenith dist.	57 50	Dist. 68° 21′ ....Sine	9.9682		
Sum.........	181 16	Reserved log.	9.6672	Reserved log.	9.6672
Half-sum	90 38	✱ zenith dist. 57° 50′ ...Sine	9.9276	☽ zenith dist. 55° 05′...Sine	9.9138
☽ zenith dist.	55 05	1st Rem. 35° 33′.......Cosec.	10.2355	2d Rem. 32° 48′......Cosec.	10.2662
1st Rem......	35 33	✱ Corr. 1′ 31″..........P. L.	2.0744	☽ Corr. 44′ 05″ ...... P. L.	0.6110
Half-sum	90 38	1st Corr. 2′ 15″..........P. L.	1.9047	2d Corr. 1° 2′ 40″......P. L.	0.4582
✱ zenith dist.	57 50				
2d Rem......	32 48				

Apparent distance.................			68° 20′ 45″
First correction ....add			2 15
Correction ☽ altitude..............			44 05
			69 07 05
Second correction...	1° 2′ 40″		
Correction ✱ altitude	1 31	sub.	1 4 11
Corrected distance................			68 02 54
Correction Table XX. — 18″			7
			68° 03′ 01″ agreeing within 1″ of the first method.

This method, as well as the first, was invented by the author of this work, who also improved Witchell's method, and reduced considerably the number of cases. These improvements were made in consequence of a suggestion of the late Chief Justice Parsons, (a gentleman eminently distinguished for his mathematical acquirements,) who had somewhat simplified Witchell's process; and it was found, upon examination, that this improvement could be extended farther than he had done it, and that the number of cases, with the manner of applying the corrections, could be rendered more simple and symmetrical. This improvement of Witchell's process we shall now insert as the fourth method of computation.

FOURTH METHOD

Of finding the true distance of the moon from the sun, a planet, or a star

RULE.

From the sun's refraction (Table XII.) take his parallax in altitude, (Table XIV.;) the remainder will be *the correction of the sun's altitude.* In like manner, if a planet be used, we must find the planet's refraction, (in Table XII.) and subtract from it the parallax in altitude, (Table X. A.;) *the remainder will be the correction of the planet's altitude.* But if a star be observed, we must find the refraction, (Table XII.;) and that will be *the correction of the star's altitude.**

From the proportional logarithm of the moon's horizontal parallax, (increasing the index by 10,) take the cosine of the moon's apparent altitude, (Table XXVII.;) the remainder will be the proportional logarithm of the moon's parallax in altitude; from which subtracting the moon's refraction, (Table XII.) the remainder will be *the correction of the moon's altitude.*†

---

* This correction may be found in Table XVII. or XVIII., as is shown in a note to the third method, in page 242.

† This correction may be found by Table XIX., as is shown in a note to the third method, in page 242.

Digitized by Google

1. Add together the apparent altitudes of the moon and sun, (planet or star,) and take the half-sum; subtract the least altitude from the greatest, and take the half-difference; then add together

The tangent of the half-sum,
The cotangent of the half-difference,
The tangent of half the apparent distance;

The sum (rejecting 20 in the index) will be the tangent of the angle A, which must be sought for in Table XXVII., and taken out less than 90° when the sun's altitude is less than the moon's, otherwise greater than 90°.* The *difference* of the angle A, and half the apparent distance, is to be called the *first angle*, and their *sum* the *second angle*.

2. Add together the tangent of the first angle,
The cotangent of the sun, planet, or star's apparent altitude,
The prop. log. of the correction of the sun, planet, or star's altitude;
The sum (rejecting 20 in the index) will be the prop. log. of the *first correction*.

Or the refraction (Table XII.) corresponding to the first angle, or its supplement, will be the first correction nearly; particularly if the altitude of the sun, planet, or star, be great, and the first angle be near 90°.

3. Add together the tangent of the second angle,
The cotangent of the moon's apparent altitude,
The prop. log. of the correction of the moon's altitude;
The sum (rejecting 20 in the index) will be the prop. log. of the *second correction*.

4. The first correction is to be added to the apparent distance when the first angle is less than 90°, otherwise subtracted; and in the same manner the second correction is to be added when the second angle is less than 90°, otherwise subtracted. By applying these two corrections, we shall obtain the corrected distance.

Enter Table XX., and find the numbers which most nearly agree with the observed distance and the observed altitudes of the objects, and take out the corresponding third correction in seconds, which is to be added to the corrected distance, and then 18″ subtracted from the sum; the remainder will be the true distance.

We shall now give an example of this fourth method of correcting the distances omitting, as before, the preparation and the computation of the longitude from the true distance.

EXAMPLE XI.

[The same as Example I., preceding.]

Suppose the apparent distance of the centre of the moon from the star Aldebaran was 68° 20′ 45″, the apparent altitude of the star 32° 10′, the apparent altitude of the moon's centre 34° 55′, and the moon's horizontal parallax 55′ 24″. Required the true distance of the moon from the star

☽ app. alt. 34° 55′			
✱ app. alt. 32 10			
Sum...... 67 05	Half-sum.. 33° 33′.. Tang. 9.82161	Hor. par. 55′ 24″....P. L. 10.5118	
Difference 2 45	Half-diff... 1° 23′ Cotang. 11.61711	☽ app. alt. 34° 55′... Cosine 9.9138	
	Half-dist... 34° 10′..Tang. 9.83171	45′ 26″....P. L. 0.5980	
	Angle A... 86° 56′..Tang. 11.27043	1′ 21″	☽ refraction.
Difference is.........	1st angle.. 52° 46′..Tang. 10.1192	44 05	Corr. ☽ altitude.
	✱ app. alt. 32° 10′ Cotang. 10.2014		
	Corr. ✱ alt. 1′ 31″..P. L. 2.0744	Apparent distance......	68° 20′ 45″
	1st Corr... 0′ 44″..P. L. 2.3950	1st correction.......add	0 44
Sum is..............	2d angle.. 121° 06′..Tang. 10.2195		68 21 29
	☽ app. alt. 34° 55′ Cotang. 10.1561	2d correction.......sub.	18 34
	Corr ☽ alt. 44′ 05″..P. L. 0.6110	3d angle.............	68 02 55
	2d Corr.... 18′ 34″..P. L. 0.9866	3d corr. Table XX.—18″	7
		True distance...........	68 03 02

Agreeing within 2″ of the first method.

* Every cotangent in Table XXVII. corresponds to two angles, the one greater than 90°, the other less than 90°

Digitized by Google

Method of correcting for the second differences of the motions of the bodies in computing a lunar observation.

In all the preceding calculations, we have neglected the second differences of the moon's motion, in the intervals of 3 hours, between the times in which the distances are marked in the Nautical Almanac. The correction arising from this source is generally quite small, and may, in most cases, be neglected, as coming within the limits of the usual errors of such observations. It is, however, very easy to find this correction by means of the following table, which is similar to that in page 484 of the Nautical Almanac for 1836. In using this table, we must find the difference between the two proportional logarithms, corresponding to the distances in the Nautical Almanac, which include the given distance. This difference is to be sought for at the top of the table; and at the side we must find the interval which is calculated in the last part of the process of computing the true longitude, being the time between the hour marked first in the Nautical Almanac, and the mean time of observation at Greenwich. The number of seconds in the table corresponding to these two arguments is to be applied, according to the directions in the table, as a correction to the time at Greenwich, computed by either of the preceding methods.

Example 1. Thus, in the example page 232, we find that the two proportional logarithms corresponding, on January 6th, to 3^h and 6^h, are 2872, 2864, whose difference is 8; and the interval past 3^h, computed in page 232, is $0^h\ 41^m\ 14^s$. Entering the table with 8 at the top, and $0^h\ 40^m$ at the side, (which is the nearest number to the interval $0^h\ 41^m\ 14^s$,) we get the correction 2^s, to be added to the time at Greenwich, $3^h\ 41^m\ 14^s$, (computed in page 232,) because the logarithms are decreasing; hence the corrected time at Greenwich is $3^h\ 41^m\ 16^s$.

Example 2. In the example page 237, we find that the two proportional logarithms corresponding, on June 20th, to 9^h and 12^h, are 2985 and 2969, whose difference is 16. Under this, and opposite the interval $1^h\ 55^m\ 28^s$, computed in page 237, (or the nearest tabular number $2^h\ 0^m$,) we find a correction 4^s to be added to the time at Greenwich $10^h\ 55^m\ 28^s$, computed in page 237, making the corrected time at Greenwich $10^h\ 55^m\ 32^s$.

Table, showing the Correction required on account of the Second Differences of the Distances in the Nautical Almanac, in working a Lunar Observation.

Find at the *top* of the table the difference between the proportional logarithm taken from the Nautical Almanac, in working a lunar observation, and that which immediately follows it, and at the side the *interval* between the hour marked in the Nautical Almanac, and the mean time of the observation of the meridian at Greenwich. The corresponding number is a correction, in seconds, which is to be *added* to the time at Greenwich, deduced from either of the preceding methods of working a lunar observation if the proportional logarithms are *decreasing*, but *subtracted* if the proportional logarithms are *increasing*; the sum or difference will be the corrected time at Greenwich.

Approximate Interval.		*Difference of the Proportional Logarithms in the Nautical Almanac.*																								*Approximate Interval.*	
		4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84	88	92	96		
		Correction of the Time at Greenwich for Second Differences.																									
H. M.	H. M.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	H. M.	H. M.
0 0	3 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 0	3 0
0 10	2 50	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	6	6	6	6	0 10	2 50
0 20	2 40	1	1	2	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	0 20	2 40
0 30	2 30	1	2	2	3	3	4	5	6	6	7	8	8	9	10	10	11	12	13	13	14	14	15	16	17	0 30	2 30
0 40	2 20	1	2	3	3	4	5	6	7	8	9	10	10	11	12	13	14	15	16	16	17	18	19	20	21	0 40	2 20
0 50	2 10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	0 50	2 10
1 00	2 00	1	2	3	4	6	7	8	9	10	11	12	13	14	16	17	18	19	20	21	22	23	24	25	27	1 00	2 00
1 10	1 50	1	2	4	5	6	7	8	9	11	12	13	14	15	17	18	19	20	21	22	24	25	26	27	28	1 10	1 50
1 20	1 40	1	3	4	5	6	7	9	10	11	12	14	15	16	17	19	20	21	22	23	25	26	27	28	29	1 20	1 40
1 30	1 30	1	3	4	5	6	8	9	10	11	12	14	15	16	18	19	20	21	23	24	25	26	27	29	30	1 30	1 30

Digitized by Google

Method of taking a lunar observation by one observer.

Three observers are required to make the necessary observations for determining the longitude; one to measure the distance of the bodies, and the others to take the altitudes. In case of not having a sufficient number of instruments or observers to take the altitudes, it has been customary to calculate them; there being given the latitude of the place, the apparent time, the right ascensions, and the declinations of the objects. These calculations are long, when an altitude of a star is to be computed, and much more so when that of the moon is required; and a considerable degree of accuracy is required in finding, from the Nautical Almanac, the moon's right ascension and declination, which must be liable to some error on account of the uncertainty of the ship's longitude. The following method of obtaining those altitudes is far more simple, and sufficiently accurate. This method depends on the supposition that the altitudes increase or decrease uniformly.

Before you measure the distance of the bodies, take their altitudes, and note the times by a chronometer; then measure the distance, and note the time, (or you may measure a number of distances, and note the corresponding times, and take the mean of all the times and distances for the time and distance respectively;) after you have measured the distances, again measure the altitudes, and note the times; then, from the two observed altitudes of either of the objects, the sought altitude of that object may be found in the following manner:—

Add together the proportional logarithm (Table XXII.) of the variation of altitude* of the object between the two times of observing the altitudes, and the prop. log. of the time elapsed between taking the first altitude and measuring the distance; from the sum subtract the prop. log.† of the time elapsed between observing the two altitudes of that object; the remainder will be the prop. log. of the correction, to be applied to the first altitude, additive or subtractive, according as the altitude was increasing or decreasing; to the altitude, thus corrected, apply the correction for dip of the horizon and semidiameter, as usual.

EXAMPLE.

Suppose the distances and altitudes of the sun and moon were observed, as in the following table; it is required to find the altitudes at the time of measuring the mean distance.

Observations.

	Times by chronometer.	*Dist.* ☉ *and* ☾ *N. L.*
	$2^h\ 3^m\ 20^s$	40° 0′ 00″
	2 4 20	40 0 30
	2 5 50	40 1 30
Mean....	2 4 30	40 0 40

	Times by chronometer.	*Obs. alt.* ☽'*s L.L.*
	$2^h\ 2^m\ 0^s$	20° 46′
	2 6 10	21 20
Difference..	4 10	34

	Times by chronometer.	*Obs. alt.* ☉'*s L.L.*
	$2^h\ 2^m\ 30^s$	40° 20′
	2 7 00	39 12
Difference..	4 30	1 8

Variation ☽'s altitude..	34′	Prop. log. 7238
Time 1st observation ☽	$2^h\ 2^m\ 0^s$	
Mean time of observing distance..........	2 4 30	
Difference..........	2 30	Prop. log. 1.8573
		2.5811
Elapsed time between the two observations	$4^m\ 10^s$	Prop. log. 1.6355
Correction of altitude...	0° 20′	Prop. log. 9456
First altitude of moon ..	20 46	add.
Alt. ☽'s L. L. at time of the mean obs. of dist.	21 6	

Variation ☉'s altitude,	1° 8′	Prop. log. 4228
Time 1st observation ☉	$2^h\ 2^m\ 30^s$	
Time mean observation	2 4 30	
Difference	2 00	Prop. log. 1.9542
Sum		2.3770
Elapsed time between the two observations	4 30	Prop. log. 1.6021
Correction of altitude...	0° 30′	Prop. log. 7749
Sub. from ☉'s 1st altitude	40 20	
Alt. ☉'s L. L. at time of the mean observation of the distances.....	39 50	

Thus, at the time $2^h\ 4^m\ 30^s$, the mean observed distance of the sun and moon's nearest limbs was 40° 0′ 40″, the altitude of the moon's lower limb 21° 6′, and the altitude of the sun's lower limb 39° 50′; these altitudes must be corrected for dip and semidiameter as usual.

---

* Table XXII. is only calculated as far as 3°, and if the variation of altitude exceed that quantity, you must enter the table with minutes and seconds, instead of degrees and minutes; and the correction of altitude taken out in minutes and seconds must be called degrees and minutes respectively.

† Or add its arithmetical complement, neglecting 10 in the index of the sum.

Digitized by Google

In this manner I have often obtained the altitudes in much less time than they could have been obtained by other calculations.

The same method may be used for finding the sun's altitude, when taking an azimuth, by noting the times of taking the observations by a chronometer, and taking two altitudes, the one before, the other after the observation, and proportioning he altitudes as above.

Any person who wishes to calculate strictly the apparent altitudes, may proceed according to the following rules:—

The apparent time, the ship's latitude and longitude, and the sun's declination given, to find the apparent altitude of his centre.*

RULE.

With the apparent time from noon, enter Table XXIII., and from the column of rising take out the logarithm corresponding, to which add the log. cosine of the latitude, and the log. cosine of the sun's declination; their sum (rejecting 20 in the index) will be the logarithm of a natural number, which being subtracted from the natural cosine of the sum of the declination and latitude, when they are of different names, or the natural cosine of their difference, when of the same name, will leave the natural sine of the sun's *true* altitude at the given time. The refraction, less parallax, being added to the true altitude, will give the *apparent* altitude.

In general, it will be near enough to take out the refraction only from Table XII., and neglect the parallax.

EXAMPLE I.

Required the true altitude of the sun's centre, in latitude 49° 57′ N., and longitude 75° W., July 26, 1836, at $6^h\ 56^m\ 30^s$ in the morning, *apparent* time, sea account.

	$12^h\ 0^m\ 0^s$		
Apparent time..........	6 56 30		
Apparent time from noon	5 3 30	Its log. in column of rising....	4.87850
Latitude...............	49 57 0 N.	Its log. cosine................	9.80852
Declination at that time..	19 24 15 N	Its log. cosine................	9.97460
		Natural number 45880 Its log. =	4.66162
Difference.............	30 32 45	Natural cosine 86123	
True altitude	23 44	Natural sine .. 40243	
Refraction..........add	2		
Apparent altitude.......	23 46		

EXAMPLE II.

What will be the true altitude of the sun's centre, in the latitude of 39° 20′ N., and the longitude of 40° 50′ W., November 26, 1836, at $3^h\ 21^m\ 30^s$, *apparent* time, in the afternoon, sea account?

Apparent time from noon	$3^h\ 21^m\ 30^s$	Its log. in column of rising	4.55900
Latitude..............	39 20 00 N.	Its log. cosine................	9.88844
Declination at that time	20 53 09 S.	Its log. cosine................	9.97048
		Natural number 26177 Its log. =	4.41792
Sum	60 13 09	Natural cosine 49668	
True altitude	13 35	Natural sine... 23491	
Refraction ....add	4		
Apparent altitude	13 39		

* If the *mean* time be given, we must deduce from it the *apparent* time, by applying the equation Table IV. A., with a *different* sign from that in the table, as taught in the introduction to the tables remarking, however, this equation is found more correctly in page II. of the Nautical Almanac.

Digitized by Google

The apparent time, with the latitude and longitude of the ship, given, to find the apparent altitude of the moon's centre.

Turn the longitude into time, (by Table XXI.) and if in west longitude add it to, but in east longitude subtract it from, the apparent time * at the ship; the sum or difference will be the apparent time at Greenwich. From this we may deduce the mean time at Greenwich, which is wanted in finding the moon's right ascension and declination.

Take the sun's right ascension from the Nautical Almanac for the preceding noon at Greenwich, and add thereto the correction taken from Table XXXI. corresponding to the hours and minutes of the time at Greenwich; the sum will be the sun's right ascension, which, being added to the apparent time at the ship, will give the right ascension of the meridian, rejecting 24 hours when the sum exceeds 24 hours.

Take from the Nautical Almanac the moon's right ascension and declination for the time at Greenwich; then the difference between the moon's right ascension and the right ascension of the meridian, will be the moon's distance † from the meridian, with which enter Table XXIII., and take out the corresponding logarithm from the column of rising, and add thereto the log. cosine of the latitude of the ship, and the log. cosine of the declination of the moon; the sum (rejecting 20 in the index) will be the logarithm of a natural number, (Table XXVI.) which, being subtracted from the natural cosine (Table XXIV.) of the sum of the declination and latitude when of different names, or the natural cosine of their difference when of the same name, will leave the natural sine of the moon's true altitude; from which subtracting the correction corresponding to the altitude in Table XXIX.‡ there will remain the *apparent* altitude nearly.

EXAMPLE.

What was the moon's apparent altitude, April 29, 1836, sea account, at $7^h\ 55^m\ 52^s$ P. M., in latitude 42° 34′ S., longitude 65° 07′ 30″ W., from Greenwich?

April 29, sea account, or by astronomical account............April 28	$7^h\ 55^m\ 52$
Longitude 65° 07′ 30″ W., in time..	4 20 30
Apparent time at Greenwich.............................April 28	12 16 22
Sun's right ascension, April $28^d\ 12^h\ 16^m\ 22^s$, by Nautical Almanac.....	$2^h\ 25^m\ 11^s$
Apparent time at the ship..	7 55 52
Right ascension of the meridian..	10 21 03
☽'s right ascension in time..	12 33 27
☽'s distance from the meridian..	2 12 24
Corresponding to which, in the column log. rising, is.................	4.21027
Latitude .... 42° 34′ S. ....Cosine	9.86717
☽'s declination......... 0 16 N. ....Cosine	10.00000
Natural number 11952 Log...	4.07744

Sum..................	42 50	Natural cosine .	73333
☽'s true altitude.........	37 52	Natural sine...	61381
Correction Table XXIX.	44		
☽'s apparent altitude....	37 08 nearly.		

This altitude would be decreased nearly 2′, if the true correction of the altitude, corresponding to the ☽'s horizontal parallax, 59′, were used, as may be seen in note ‡, at the bottom of the page.

* The apparent time is counted from noon to noon, marking the hours from 1 hour to 24 hours. We may remark, that this process of finding the time at Greenwich is unnecessary when you have a chronometer regulated for *mean* time at Greenwich, because we can immediately obtain the *apparent* time, by applying the equation of time, taken from the Nautical Almanac, or from Table IV. A., using a different sign from that in the table.

† When the distance exceeds 12 hours, you must enter Table XXIII. with the difference between that distance and 24 hours.

‡ In strictness you ought, instead of this correction, to use the correction of the moon's altitude corresponding to her apparent altitude and horizontal parallax. This is easily found in Table XIX., using the ☽'s horizontal parallax and the apparent altitude found by the above process, and subtracting the tabular correction from 59′ 42″. Thus, if the ☽'s horizontal parallax is 59′, and the ☽'s apparent altitude 37° 8′, this correction would be 59′ 42″—13′ 55″=45′ 47″, instead of 44′, which is used above.

Digitized by Google

The apparent time, with the latitude and longitude of the ship, being given, to find the apparent altitude of the centre of a planet.

Turn the longitude into time, (by Table XXI.;) and if west, add it to, but if east longitude, subtract it from, the apparent time at the ship; the sum, or difference, will be the apparent time at Greenwich. From this we may deduce the mean time at Greenwich, which is required in finding the right ascension and declination of the planet.*

Take the sun's right ascension from the Nautical Almanac, for the preceding noon at Greenwich, and add thereto the correction taken from Table XXXI., corresponding to the hours and minutes of the time at Greenwich; the sum will be the sun's right ascension, which, being added to the apparent time at the ship, will give the right ascension of the meridian, rejecting 24 hours when the sum exceeds 24 hours.

Take from the Nautical Almanac the planet's right ascension and declination for the time at Greenwich; then the difference between the planet's right ascension and the right ascension of the meridian, will be the planet's distance † from the meridian; with which enter Table XXIII., and take out the corresponding logarithm, from the column of rising, and add thereto the log. cosine of the latitude of the ship, and the log. cosine of the declination of the planet; the sum (rejecting 20 in the index) will be the logarithm of a natural number, (Table XXVI.) which, being subtracted from the natural cosine (Table XXIV.) of the sum of the declination and latitude when of different names, or the natural cosine of their difference when of the same name, will leave the natural sine of the planet's true altitude; to which add the correction of altitude for parallax and refraction, and we shall get the apparent altitude; observing that this correction is found in Table XVII., in the page corresponding to the horizontal parallax of the planet; the difference between the tabular number and 60 being the correction of the planet's altitude for refraction and parallax.

EXAMPLE.

What was the planet Jupiter's apparent altitude, April 29, 1836, sea account, at $7^h\ 55^m\ 52^s$ P. M., in latitude 42° 34′ S., longitude 65° 7′ 30″ W. from Greenwich?

April 29, sea account, is by astronomical account........... April 28^d	7^h	55^m	52^s
Longitude 65° 07′ 30″ W., in time........................	4	20	30
Apparent time at Greenwich.......................... April 28	12	16	22
☉'s right ascension,‡ April $28^d\ 12^h\ 16^m\ 22^s$ by Nautical Almanac	2	25	11
Apparent time at the ship..................................	7	55	52
Right ascension of the meridian	10	21	03
♃'s right ascension, in time	6	47	08
♃'s distance from the meridian..................................	3	33	55

Corresponding to which, in the column of log. rising, is.............				4.60733
Latitude	42° 34′ S.		Cosine	9.86717
Declination	23 16 N.		Cosine	9.96316
		Natural number 27395	Log...	4.43766
Sum....................	65 50	Natural cosine 40939		
♃'s true altitude	7° 47′	Natural sine ... 13544		
Correction Table XVII. add	7 §			
♃'s apparent altitude.....	7 54			

* This is more easily obtained by a chronometer regulated to Greenwich time, as in the preceding example of finding the altitude of the moon.

† When the distance exceeds 12 hours, you must enter Table XXIII. with the difference between that distance and 24 hours.

‡ The sun's right ascension at noon, April 28, is $2^h\ 23^m\ 15^s$, and the horary motion $9^s.484$, which, for $12^h\ 16^m\ 22^s$, gives, by Table XXXI., 116″ = 1′ 56″ nearly; adding this to $2^h\ 23^m\ 15^s$, we get the ☉'s right ascension $2^h\ 25^m\ 11^s$. The planet's right ascension and declination are found by inspection in the Nautical Almanac.

§ This correction is found in page 89, Jupiter's parallax being only 1″.5. The tabular correction corresponding to the apparent altitude 7° 54′ is 53′ 26″; subtracting this from 60′, we get 6′ 34″, or nearly 7′, for the correction arising from the refraction and parallax

Digitized by Google

The apparent time, the latitude and longitude, given, to find the apparent altitude of a fixed star.

RULE.

Turn the longitude into time, and add it to, or subtract it from, the apparent time * at the ship, according as the longitude is west or east; the sum or difference will be the time at Greenwich. The apparent time at Greenwich may also be found by means of a chronometer, as in the preceding example, page 248.

Find, in the Nautical Almanac, the sun's right ascension for the noon preceding the time at Greenwich, and add thereto the correction corresponding to the hours and minutes of the time at Greenwich, (using Tables XXX. XXXI. if necessary;) the sum will be the sun's right ascension, which being added to the *apparent* time at the ship, will give the *right ascension of the meridian*, rejecting 24 hours when the sum exceeds 24 hours.

Find the star's right ascension and declination in the Nautical Almanac, or by means of Table VIII., as taught in page 217.

The difference between the star's right ascension and the right ascension of the meridian, will be *the distance of the star from the meridian.*

Find in the column of rising of Table XXIII. the logarithm corresponding to the star's distance from the meridian,† and add thereto the log. cosine of the latitude of the ship, and the log. cosine of the declination of the star; the sum (rejecting 20 in the index) will be the logarithm of a natural number, (Table XXVI.) which being subtracted from the natural cosine (Table XXIV.) of the *sum* of the declination and latitude when of different names, or the natural cosine of their difference when of the same name, will leave the natural sine of the star's *true* altitude.

The refraction being added to the true altitude, will give the *apparent* altitude.

EXAMPLE.

What was the apparent altitude of Aldebaran, at Philadelphia, April 12, 1836, sea account, at $5^h\ 57^m\ 18^s$ in the afternoon, *apparent* time?

The star's right ascension and declination are found by inspection in the Nautical Almanac, as below; this being the shortest and most accurate method of finding them.

	h	m	s		
App. time by astronomical account, April 11ᵈ	5	57	18		
Longitude 75° 9′ W.	5	0	36		
Time at Greenwich .... April 11	10	57	54		
☉'s right ascension, April 11, at noon, by N.A.	1	19	54		
Variation for $10^h\ 57^m\ 54^s$ by Table XXXI.		1	41		
☉'s right ascension at the time of observation	1	21	35		
Apparent time of observation	5	57	18		
Right ascension of the meridian	7	18	53		
✱'s right ascension by Nautical Almanac	4	26	30		
✱'s distance from the meridian †	2	52	23	Its log. in col. rising	4.43102
Latitude of Philadelphia.. 39° 57′ N.				Cosine	9.88457
✱'s declination .... 16 10 N.				Cosine	9.98248
				Natural number 19864 .... Its log.	4.29807
Difference 23 47				Natural cosine . 91508	
True altitude 45 46				Natural sine ... 71644	
Refraction .... add 1					
Apparent altitude 45 47					

* The apparent time must be taken (as usual) one day less than the sea account, and the hour must be reckoned from noon to noon in numerical succession from 1 to 24. It may also be observed that, if the observer be furnished with a chronometer, regulated to mean Greenwich time, this part of the operation may be saved, reducing the *mean* time to *apparent*, by applying the equation Table IV. A., or that found in the Nautical Almanac, as in the preceding rules.

† If the distance from the meridian exceed 12 hours, you must subtract it from 24 hours, before entering Table XXIII.

Digitized by Google

Method of combining several lunar observations together.

As a lunar observation is liable to some degree of uncertainty, on account of the imperfections of the instruments, the unavoidable errors of the observations, and the imperfections in the reductions, it will generally be conducive to accuracy to combine together several observations, taken on the same day, or on two or three successive days; and this may be done in the following manner:—

After working the lunar observation, and finding the mean time of the observation on the meridian of Greenwich, by either of the preceding methods, we must compare this time with the corresponding time of observation, as shown by the chronometer, and the difference will be the error of the chronometer for mean time at Greenwich, as shown by that lunar observation. Other observations, being taken on the same, or on successive days, and computed in the same manner, will also give the errors of the chronometer, corresponding to these observations respectively. The mean of all these errors, being found, will represent very nearly the error of the chronometer, relative to the mean time at Greenwich, and corresponding to that moment of time which results from taking the mean of all the times of observation at Greenwich, for all the lunar observations.

Having obtained in this way the error of the chronometer relative to Greenwich time, and knowing its daily rate of loss or gain, we can determine at any moment the mean time at Greenwich, by the chronometer, as it is given by the mean of all these observations. Comparing this mean time with the corresponding mean time at the same moment at the ship, as found by taking the sun's altitude, or by any other of the methods explained in pages 208—218, the difference will be the longitude of the ship, resulting from the mean of all these observations.

EXAMPLE I.

Times by the Chronometer.	*Mean Times at Greenwich by Lunar Observations.*	*Errors of the Chronometer for Greenwich Time.*
April 6d 2h 10m 20s	April 6d 2h 12m 20s	2m 00s
2 30 18	2 32 38	2 20
3 40 25	3 42 05	1 40
4 20 15	4 22 25	2 10
5 16 16	5 18 34	2 18
6 01 20	6 03 16	1 56
Sum . . . 6)23 58 54	6)24 11 18	6)12 24
Mean, April 6d 3h 59m 49s	April 6d 4h 01m 53s	2m 04s

Hence it appears, that, by the mean of the six lunar observations, when the time by the chronometer was, April 6d, 3h 59m 49s, it was 2m 04s too slow for mean time at Greenwich.

We shall now suppose, that, on April 6d 4h 30m 00s, by the chronometer, an altitude of the sun was taken, and the mean time at the ship deduced therefrom, April 6d 6h 24m 56s, and that it was required to find the longitude of the ship; the chronometer moving uniformly without gain or loss; we shall have

Time by the chronometer..........................	April 6d	4h 30m 00s
Error of the chronometer by the lunar observations.....add		2 04
Mean time at Greenwich	April 6	4 32 04
Mean time at the ship............................	April 6	6 24 56
Longitude east of Greenwich..........................		1 52 52 = 28° 13

EXAMPLE II.

Times by the Chronometer.	*Mean Times at Greenwich by Lunar Observations.*	*Errors of the Chronometer for Greenwich Time.*
July 6d 3h 15m 06s	July 6d 3h 17m 16s	2m 10s
7 4 16 15	7 4 18 23	2 08
8 5 17 12	8 5 19 24	2 12
3)21 12 48 33	3)21 12 55 03	3)6 30
Mean, July 7d 4h 16m 11s	July 7d 4h 18m 21s	2m 10s

Digitized by Google

The mean of these three observations makes the chronometer too slow for Greenwich time $2^m\ 10^s$; and if we suppose the instrument to be well regulated for mean time, and on July $8^d\ 4^h\ 10^m\ 15^s$ by the chronometer, the mean time at the ship deduced from the sun's altitude, was July $8^d\ 2^h\ 15^m\ 25^s$, we shall have,

Time by chronometer	July	8^d	4^h	10^m	15^s
Error by the lunar observations	add			2	10
Mean time at Greenwich	July	8	4	12	25
Mean time at the ship	July	8	2	15	25
Longitude west of Greenwich			1	57	00 = 29° 15′

This process may be used for regulating a chronometer when it has accidentally stopped, or has been allowed to run down. For, by comparing the two above examples, supposing them to have been taken by the same chronometer,

The first set gives the error April $6^d\ 3^h\ 59^m\ 49^s$	equal to	+ $2^m\ 04^s$
The second set gives the error July 7 4 16 11	equal to	+ 2 10
Gain in 92 days		+ 6^s

This is, however, an imperfect method of determining the daily gain or loss of the chronometer, on account of the imperfection of the observations; and is only to be used in cases of absolute need.

To find the longitude by the eclipses of Jupiter's satellites.

The eclipses of the satellites are given in the Nautical Almanac for *mean* time at Greenwich, and also for sideral time. There are two kinds of these eclipses—an *immersion*, denoting the instant of the disappearance of the satellite by entering into the shadow of Jupiter, and an *emersion*, or the instant of the appearance of the satellite in coming from the shadow. The immersions and emersions generally happen when the satellite is at some distance from the body of Jupiter, except near the opposition of Jupiter to the sun, when the satellite approaches to his body. Before the opposition, they happen on the west side of Jupiter, and after the opposition, on the east side. But if an astronomical telescope is used, which reverses the objects, the appearance will be directly the contrary. The configurations, or the positions in which Jupiter's satellites appear at Greenwich, are given, in the Nautical Almanac, every night, when visible.

As these eclipses happen almost daily, they afford the most ready means of determining the longitude of places on land, and might also be applied at sea, if the observations could be taken with sufficient accuracy in a ship under sail, which can hardly be done, since the least motion of a telescope which magnifies sufficiently to make these observations, would throw the object out of the field of view.

Having regulated your chronometer for *mean* time at the place of observation, you must then find nearly the mean time at which the eclipse will begin at that place: this may be done as follows:—Find from the Nautical Almanac the *mean* time of an immersion, or emersion, and apply thereto the longitude turned into time, by adding when in east, but subtracting when in west longitude; the sum or difference will be nearly the *mean* time when the eclipse is to be observed at the given place. If there be any uncertainty in the longitude of the place of observation, you must begin to look out for the eclipse at an earlier period; and when the eclipse begins, you must note the time by the chronometer, and after applying the correction for the error of the chronometer, if there be any, you will have the *mean* time of the eclipse at the place of observation; the difference between this and the *mean* time in the Nautical Almanac, being turned into degrees, will be the longitude from Greenwich.

EXAMPLE.

Suppose that, on the 21st of August, 1836, sea account, in the longitude of 127° 55′ W., by account, an immersion of the first satellite of Jupiter was observed, at $10^h\ 24^m\ 47^s$ P. M. mean time. Required the longitude.

By Nautical Almanac, the time of immersion is,	August 20th	19^h	0^m	7^s
By observation, August 21, sea account, or by N A.	August 20th	10	24	47
Longitude in time		8	35	20

which, being turned into degrees, gives 128° 50′ W. for the longitude of the place of observation.

Digitized by Google

To find the longitude by an eclipse of the moon.

The determination of the longitude by an eclipse of the moon, is performed by comparing the times of the beginning or ending of the eclipse, as also the times when any number of digits are eclipsed, or when the earth's shadow begins to touch or leave any remarkable spot in the moon's face; the difference of these times between the like observations made at different places, turned into degrees, will be the difference of longitude of those places.

When the beginning or end of an eclipse of the moon is observed at any place, the longitude of that place may be easily found by comparing the time of observation with the time given in the Nautical Almanac; for the difference between the observed mean time of beginning or ending, and the mean time given in the Nautical Almanac, will be the ship's longitude in time, which may be turned into degrees by Table XXI. Thus, if the beginning of an eclipse of the moon was observed October 25, 1836, sea account, at $5^h\ 21^m$, mean time; the mean time at Greenwich by the Nautical Almanac being October 24, or October 25, sea account, at $0^h\ 38^m$, their difference, $4^h\ 43^m$, is the longitude of the place of observation $=70°\ 45'$, which is east from Greenwich, because the time at the place of observation is greatest.

To find the longitude by a perfect time-keeper or chronometer.

It was before observed, that if a chronometer could be made in so perfect a manner as to move uniformly in all places, and at all seasons, the longitude might easily be deduced therefrom, by comparing the mean time shown by the chronometer, regulated to the meridian of Greenwich, (or some other known meridian,) with the *mean* time at the place of observation; for the difference of these times would be the difference of longitude between that meridian and the place of observation. The moderate prices of good chronometers now, in comparison with their values many years since, together with the various improvements in their construction, have caused this method of determining the longitude to be very much used within a few years; we shall therefore explain fully the use of this instrument, the methods of regulating and ascertaining its rate of going, and give examples of the calculations for finding the longitude.

If a chronometer is to be used on a voyage, it must be adjusted, and its rate of going ascertained, before sailing. This is most conveniently done on shore by observing, with a transit instrument, the times of the transits of the sun, or some fixed star, over the meridian, as is taught in pages 221—224. If you have no instrument of this kind, the regulation may be made by taking altitudes* of the sun or some other heavenly body, and finding therefrom the *mean* time of observation, by any of the methods before given in pages 208—218. The best way of making these last observations on land, is by an artificial horizon of quicksilver; finding and correcting the altitudes in exactly the same way as in computing the latitude in page 204. Comparing the *mean* time of observation, obtained in this way, with the time by the chronometer, shows how much it is then too *fast* or too *slow* for the meridian of the place of observation; and by repeating the operation on a future day, the rate of going may be ascertained. If it is found to *gain* or *lose* a few seconds, or parts of a second, per day, that allowance must be made on all future observations at sea. Thus if, on the 1st of June, 1836, at $5^h\ 10^m\ 20^s$, by the chronometer, the *mean* time, deduced from an observation of the sun's altitude, was $5^h\ 12^m\ 40^s$, the chronometer would then be too slow by the difference of those times, $2^m\ 20^s$; and if, on the 21st of June following the time by the chronometer was $4^h\ 15^m\ 35^s$, when the mean time was $4^h\ 18^m\ 17^s$, the chronometer would then be too slow by the difference of those times, or $2^m\ 42^s$; and the rate would have varied, in 20 days, from $2^m\ 20^s$, to $2^m\ 42^s$, which is a difference of 22^s in 20 days, being $1^s.1$ per day; and this rate must be allowed on all future observations at sea, until a new regulation can be obtained, at some place whose longitude is known. It is best to have a considerable number of days' interval between the two observations for fixing the rate, since by this means it may be determined to tenths of a second; the absolute error of the observations being reduced, in finding the daily rate, by dividing by the number of days. Thus, if the above difference of 22^s had been erroneous 2^s, and the true value 20^s, the daily rate would be *one* second, instead of $1^s.1$, varying only one tenth of a second, notwithstanding the observations on which the rate was established contained an error of two seconds.

Having regulated a chronometer, in the manner first mentioned, at a place whose longitude from Greenwich is known, it is easy to find how much it is too fast or too

* See Tab. LVII.

Digitized by Google

slow for the meridian of Greenwich, by reducing the *mean* time at the place of the observer, as found by observations, to the meridian of Greenwich, by *adding* the longitude if west, *subtracting* if east; the sum or difference will be the *mean* time of observation in the meridian of Greenwich; the difference between this and the time given by the chronometer, shows how much it is too fast or too slow for Greenwich *mean* time. Thus, by adding the longitude, which we shall suppose to be $4^h\ 56^m$, to the *mean* time of the above observation, $5^h\ 12^m\ 40^s$, we get $10^h\ 8^m\ 40^s$ for the *mean* time at Greenwich; from which subtracting the time by the chronometer, $5^h\ 10^m\ 20^s$, we obtain $4^h\ 58^m\ 20^s$ for the error of the chronometer relative to mean time at Greenwich; being too *slow* for that time.

The chronometer having been thus regulated to Greenwich time, and the daily rate of its going ascertained, if this rate should remain unaltered, the time at Greenwich will be known by it, at any moment at sea; and if at that moment, by any observation of the sun, moon, planet, or a fixed star, the *mean* time at the ship be found by any of the methods explained in pages 208, &c., the difference between this *mean* time at the ship, and the *mean* time at Greenwich, shown by the chronometer, will be the longitude, which may be turned into degrees and minutes by Table XXI.

EXAMPLE I.

Wishing to regulate a chronometer, in a place whose latitude is 51° 30′ N., and longitude 130° E. from Greenwich, I observed, October 10, 1864 at $8^h\ 21^m$ A. M., sea account, by a chronometer, the altitude of the sun's lower limb, by a fore observation, 13° 32′, the correction for semidiameter, parallax, and dip, being 12′. It is required to find the error of the chronometer for *mean* time at Greenwich.

The *mean* time of this observation, at the meridian of the ship, computed as in Example I., page 209, is $7^h\ 54^m\ 50^s$ A. M., or October $9^d\ 19^h\ 54^m\ 50^s$, astronomical account. From this subtract* the longitude 130°, turned into time $8^h\ 40^m$, (by Table XXI.) we get the corresponding *mean* time at Greenwich, Oct. 9^d, $11^h\ 14^m\ 50^s$; and as the time by the chronometer is, October 9^d, $20^h\ 21^m\ 00^s$, it is too fast for mean time at Greenwich by the difference of those two quantities, or $9^h\ 6^m\ 10^s$.

EXAMPLE II.

May 10, 1836, at $5^h\ 30^m$ P. M., sea account, by a chronometer, in latitude 39° 54′ N., in a place whose longitude was known to be 35° 45′ E. from Greenwich, the altitude of the sun's lower limb by a fore observation was 15° 45′, the correction for dip, parallax, and semidiameter, being 12′. It is required to find the error of the chronometer for *mean* time at Greenwich.

The mean time of this observation, computed as in Example II., page 210, is May $9^d\ 5^h\ 30^m\ 39^s$, astronomical computation. From this subtract* the longitude, 35° 45′, turned into time, $2^h\ 23^m$, by Table XXI.; the remainder, May $9^d\ 3^h\ 7^m\ 39^s$, is the *mean* time at Greenwich. The difference between this and the time by the chronometer, $5^h\ 30^m$, is $2^h\ 22^m\ 21^s$, which expresses how much the chronometer is too fast for Greenwich mean time.

EXAMPLE III.

Suppose that, on July 27, 1836, sea account, the mean time was found, by an altitude of the sun, to be $1^h\ 11^m\ 16^s$ P. M., when, by a chronometer well regulated to *mean* time at Greenwich, it was $4^h\ 3^m\ 8^s$ P. M. Required the longitude.

Mean time at the place of observation	$1^h\ 11^m\ 16^s$
Time at Greenwich by chronometer..	4 3 8
Difference in the longitude..........	2 51 52 = 42° 58′ W., the longitude being

west, because the time at Greenwich is the greatest.

EXAMPLE IV.

Suppose that, on May 14, 1836, sea account, the mean time was found, by an altitude of the sun, to be $3^h\ 59^m\ 09^s$ P. M., when the time by the chronometer was

* This is to be *added*, if the ship's longitude is *west*

Digitized by Google

2ʰ P. M., the chronometer being too slow for mean Greenwich time 11ᵐ 9ˢ. Required the longitude.

Time by chronometer.....	2ʰ	0ᵐ	00ˢ	
Chronometer too slow for *mean* time at Greenwich.......		11	9	
Mean time at Greenwich	2	11	09	P. M.
Mean time at the ship	3	59	09	
Difference is the longitude..............................	1	48	00	= 27° 00′ E.

EXAMPLE V.

Suppose that, on June 14, 1836, sea account, in a place whose longitude from Greenwich was known, a number of observations were taken to ascertain the going of the chronometer; and it was found, that, on that day, it was 10ˢ too slow for mean Greenwich time, and lost time 2ˢ per day; and that, on July 14, 1836, sea account, the time per chronometer was 6ʰ 0ᵐ 6ˢ P. M., when, by an observed altitude of the sun, the *mean* time was 1ʰ 21ᵐ 32ˢ P. M. Required the longitude.

Error of chronometer, June 14..............................	0ʰ	00ᵐ	10ˢ	slow.
30 days, at 2ˢ		1	0	slow.
Error July 14..............................		1	10	slow.
Time per chronometer..............................	6	0	6	
Time at Greenwich	6	1	16	
Mean time at place of observation	1	21	32	
Longitude..............................	4	39	44	= 69° 56′ W.

EXAMPLE VI.

Suppose that, on June 15, 1836, in the afternoon, astronomical account, at Boston, in the latitude of 42° 21′ 15″ N., and longitude 71° 04′ 09″ W., several angular distances of the sun's lower limb, from its reflected image in a basin of quicksilver, were observed, and the times noted by a chronometer, which was supposed to be very nearly regulated for mean time at Greenwich; the times and altitudes being as below; the thermometer standing at 76°, and the barometer at 30°.05. Required the error of the chronometer relative to mean time at Greenwich.

Times by the chronometer, June 15ᵈ	7ʰ	55ᵐ	20ˢ	.... Observed angle	91°	16′	20″
		56	12	....	90	57	40
		57	01	....	90	39	48
		57	46	....	90	22	54
		58	36	....	90	04	36
		59	24	....	89	46	42
Sum		44	19	Sum....6)	543	08	00
Mean of the times .... June 15ᵈ	7ʰ	57ᵐ	23ˢ.2	.........Mean angle	90	31	20

Half the mean angle is equal to altitude ☉'s lower limb.................		45	15	40
Refraction, Table XII.—57″—Parallax, Table XIV.+ 6″=—51″				
Table XXXVI., Thermometer 76°, correction —3″ } Barometer 30°.05, correction + 1″ }	=—2			
Correction for refraction and parallax	53.......sub.			53
		45	14	47
☉'s semidiameter* by Nautical Almanac			15	46
☉'s true altitude....................		45	30	33

* In finding the sun's declination, semidiameter, &c., from the Nautical Almanac, the time at Greenwich is supposed to be the same as the mean time of the observation by the chronometer 7ʰ 57ᵐ 23ˢ.2, which is supposed to be very nearly regulated to mean time at Greenwich. If you have no chronometer regulated for that meridian, you must estimate the time at Greenwich in the usual manner, by adding to the mean time at the ship the longitude if west, or subtracting it if east

Digitized by Google

☉'s true altitude	45° 30′ 33″		
Latitude.......	42 21 15	Secant..	0.13136
Polar distance..	66 38 49	Cosecant	0.03712
Sum.......2)	154 30 37		
Half-sum......	77 15 19	Cosine..	9.34362
Remainder	31 44 46	Sine....	9.72111
		Sum 2)	19.23321

Sine of half-sum 9.61660 corresponds to $3^h\ 15^m\ 27^s.5$ app. time.

Equation of time by the Nautical Almanac.................			$+9^s.4$
Mean time at the place of observation......................	3	15	$36^s.9$
Add the longitude of Boston, in time......................	4	44	$16^s.6$
Mean time at Greenwich................................	7	59	$53^s.5$
Time by the chronometer, as above	7	57	$23^s.2$
Chronometer, error...................................slow			$2^m\ 30^s.3$

Hence it appears that, on the 15th of June, 1836, astronomical time, at $7^h\ 57^m\ 23^s.2$, by the chronometer, it was too slow for Greenwich time $2^m\ 30^s.3$. Suppose, now, that, a few days afterwards, as an example, on June 25, at about the same hour in the afternoon, a similar set of altitudes were observed, and the times noted by the same chronometer, the result of the calculation making the chronometer too slow by $2^m\ 45^s.6$; then we shall find that, in the interval of 10 days, from June 15 to June 25, it has varied by the quantity $2^m\ 45^s.6 - 2^m\ 30^s.3 = 15^s.3$. Dividing this variation by 10, (the number of days in the interval,) we get $1^s.53$ for the daily rate of loss in the chronometer. If other sets of observations are made, which give results differing a little from $1^s.53$, we can use the mean of the different sets, as the most probable value of the rate of the chronometer.

EXAMPLE VII.

On the 15th of June, 1836, astronomical account, at about $3^h\ 45^m$ P. M., in the meridian of Cape Cod, which bore south, distant about 9 miles, took four altitudes of the sun, and noted the times by the chronometer, as in the table below; the eye being 19 feet above the level of the sea, the thermometer at 65°, and the barometer at 29 inches. It is required to determine the error of the chronometer for mean time at Greenwich.

Times by the chronometer.......	8^h	25^m	36^s	...........Observed angle	40°	00′	07′
		26	32	....	39	50	18
		27	22	....	39	40	14
Sum 3)		79	30	Sum 3)	119	30	39
Mean of the three observations...	8	26	30	☉'s altitude	39	50	13
Supposed error of the chronometer for mean time at Greenwich	+1		30	Dip, Table XIII......sub.		4	17
Estimated mean time at Greenwich	8	28	00		39	45	56

Refraction, Table XII..............................	−1′ 8″			
Parallax, Table XIV..............................	+7″			
Table XXXVI. Thermometer....................	−2″			
Barometer	−1″.........sub.		1	04
		39	44	52
☉'s semidiameter			15	46
☉'s true altitude................		40	00	38

With the above estimated time at Greenwich, we find, from the Nautical Almanac, the sun's declination 23° 21′ 14″ N., the sun's semidiameter 15′ 46″, and the equation of time $+9^s.7$. The latitude of Cape Cod being 42° 3′ N., and as it is distant 9′, in a south direction, the latitude of the ship is* 42° 12′ N.

* The ship being on the meridian, we must add the whole distance 9′ to the latitude of Cape Cod, to get the latitude of the ship; but if the bearing be in any other direction, we must calculate means

☉'s true altitude	40° 00′ 38″	
Latitude.......	42 12 00	Secant.. 0.13030
Polar distance..	66 38 46	Cosecant 0.03712
Sum....... 2)	148 51 24	
Half-sum	74 25 42	Cosine.. 9.42885
Remainder	34 25 04	Sine.... 9.75222
		Sum 2) 19.34849

Sine of half-sum 9.67424 corresponds to $3^h\ 45^m\ 29^s$. app. time

Equation of time by the Nautical Almanac	$+9^s.7$
Mean time at the place of observation......................	3 45 $38^s.7$
Add the longitude of Cape Cod, 70° 4′.................. =	4 40 $16^s.0$
Mean time at Greenwich..................................	8 25 $54^s.7$
Time by the chronometer..................................	8 26 $30^s.0$
Error of the chronometer for mean time at Greenwich....fast	$35^s.3$

EXAMPLE VIII.

At New York, on the 5th of June, 1836, by a transit of the sun over the meridian, it was found that a chronometer was too fast for mean time at Greenwich, by $2^m\ 8^s.5$; and by another transit, on the next day, June 6th, it was too fast $2^m\ 10^s.0$. From these observations it follows, that the daily gain of the chronometer at that time was $1^s.5$. The instrument was then taken on board a ship, which sailed immediately on a voyage along the seacoast, and, after a passage of 10 days, arrived at a place whose longitude from Greenwich had been well ascertained. There, by observation, it was found, that at noon, June 16, 1836, the chronometer was $2^m\ 30^s.5$ too fast for mean time at Greenwich; having gained $22^s.0$ in 11 days; or at the mean daily rate of $2^s.0$, instead of $1^s.5$, which was the rate at the commencement of the voyage. Now, the chronometer being a new one, and it being generally found that the daily rate of such an instrument is constantly increasing, it is required to find the error of the chronometer at noon on every day of the voyage, supposing the daily rate of gain to increase uniformly; the object in thus finding the actual error on each day, being for the purpose of ascertaining the longitudes of several capes and places which were observed during the voyage.

The calculation of this example is made as in the annexed table. Its first column contains the days of the month. The second column contains the estimated error of the chronometer, supposing its daily gain to be $1^s.5$, as at the commencement of the voyage. The third column contains the gain of the chronometer on every successive day, supposing this uniform daily increment of the rate to be a fraction of a second, which is represented by t. The fourth column contains the error of the chronometer on each day, expressed in terms of t; the numbers in this column are found by adding successively the daily gain in column 3, to the error of the chronometer on the preceding noon. Thus, on June 13, the error at noon is $2^m\ 20^s.5 + 28\,t$, and the daily gain between June 13th and 14th is $1^s.5 + 8\,t$; adding together these two quantities, we obtain $2^m\ 22^s.0 + 36\,t$, for the error of the chronometer, June 14, at noon; being the same as in column 4. Proceeding in this way, by successive additions, we obtain the error of the chronometer, June 16, at noon, equal to $2^m\ 25^s.0 + 55\,t$; and as this was found by observation to be $2^m\ 30^s.5$, we shall have $2^m\ 25^s.0 + 55\,t = 2^m\ 30^s.5$; whence we get $55\,t = 2^m\ 30^s.5 - 2^m\ 25^s.0 = 5^s.5$. Dividing this by 55, the coefficient of t, we get $t = 0^s.1$. Hence the daily gain in the acceleration is $t = 0^s.1$; and by substituting this value of t in the errors at noon on the different days, given in column 4, we get the corresponding numbers in column 5, which represent how much the chronometer is too fast for mean time at Greenwich at each noon, from June 5 to June 16; supposing the daily acceleration of the rate to be $0^s.1$, or $\frac{1}{10}$ of a second. Taking the successive daily differences of these errors, we get, as in column 6, the daily gain of the chronometer, which increases from $1^s.5$ to $2^s.5$ during the voyage.

of the table of difference of latitude and departure, the latitude and longitude of the ship, at the time of observation, in the same manner as when taking a departure from the land. Thus, if the *true bearing* of the cape, in the above example, were S. S. W. 9′, the difference of latitude will be 8′.3, departure 3′.4, difference of longitude 4′.6; hence the latitude of the ship will be 42° 3′ + 8′.3 = 42° 11′.3 = 42° 11′ 18″, and the longitude 70° 4′ − 4′.6 = 69° 59′.4 = 69° 59′ 24′; which must, in this case, be used instead of the above values.

Digitized by Google

Col. 1.	Col. 2.	Col. 3.	Col. 4.	Col. 5.	Col. 6.
Dates.	*Error of the chronometer, supposing the daily gain to be 1ˢ.5.*	*Daily gain, supposing the rate to be uniformly increasing by the quantity t.*	*Error of the chronometer at noon each day, expressed as terms of t.*	*Error of the chronometer at noon each day in time.*	*Daily gain in seconds*
June 5.	$2^m\ 08^s.5$	$1^s.5$	$2^m\ 08^s.5$	$2^m\ 08^s.5$	$1^s.5$
" 6.	2 10 .0	$1.5+t$	2 10 .0	2 10 .0	1 .6
" 7.	2 11 .5	$1.5+2t$	$2\ 11.5+t$	2 11 .6	1 .7
" 8.	2 13 .0	$1.5+3t$	$2\ 13.0+3t$	2 13 .3	1 .8
" 9.	2 14 .5	$1.5+4t$	$2\ 14.5+6t$	2 15 .1	1 .9
" 10.	2 16 .0	$1.5+5t$	$2\ 16.0+10t$	2 17 .0	2 .0
" 11.	2 17 .5	$1.5+6t$	$2\ 17.5+15t$	2 19 .0	2 .1
" 12.	2 19 .0	$1.5+7t$	$2\ 19.0+21t$	2 21 .1	2 .2
" 13.	2 20 .5	$1.5+8t$	$2\ 20.5+28t$	2 23 .3	2 .3
" 14.	2 22 .0	$1.5+9t$	$2\ 22.0+36t$	2 25 .6	2 .4
" 15	2 23 .5	$1.5+10t$	$2\ 23.5+45t$	2 28 .0	2 .5
" 16.	2 25 .0		$2\ 25.0+55t$	2 30 .5	

EXAMPLE IX.

We shall suppose, as in the preceding example, that at noon June 5, 1836, the chronometer was too fast $2^m\ 8^s.5$, and at noon June 6, 1836, it was too fast $2^m\ 10^s.0$ indicating a daily gain of $1^s.5$. In proceeding on a voyage, the vessel stopped, on the 10th of June, 1836, at a port whose longitude was unknown; and, with a view to determine this longitude by the chronometer, observations were made, by which it was found, that between the successive noons of June 10th and June 11th, 1836, the daily gain was $2^s.0$. It is required to determine the error of the chronometer on the different days, supposing the daily gain to be uniform. The actual rate of the chronometer, is particularly required on the 10th and 11th of June, so that we may use the rate of the chronometer in finding the longitude of the place arrived at.

In the intervals of the two days, commencing June 5 and June 10, the daily gains were respectively $1^s.5$ and $2^s.0$; having increased $0^s.5$, in the daily rate, in an interval of 5 days; being at the rate of $0^s.1$ per day. With this daily increase, we can compute the daily gain, as in column 2 of the following table; and from these numbers we can deduce successively the errors of the chronometer, as in column 3.

Col. 1.	Col. 2.	Col. 3.
Dates.	*Daily rate of gain.*	*Chronometer too fast.*
June 5.	$1^s.5$	$2^m\ 08^s.5$
" 6.	1 .6	2 10 .0
" 7.	1 .7	2 11 .6
" 8.	1 .8	2 13 .3
" 9.	1 .9	2 15 .1
" 10.	2 .0	2 17 .0
" 11.		2 19 .0

Hence it appears, that on June 10, the chronometer was $2^m\ 17^s.0$ too fast for Greenwich mean time; and on June 11, it was $2^m\ 19^s.0$; which can be used in determining the longitude.

Digitized by Google

Precautions in using a chronometer.

We shall close this article on chronometers, by the following directions relative to the manner of taking care and using them, published in a small tract on this subject, by Mr. Stansbury:—In carrying a chronometer to and from a ship, you must secure the gimbals by the stay, to keep it steady; and by all means avoid giving the instrument a quick circular motion. A chronometer should be placed so as to expose it as little as possible to sudden shocks, from the sea striking the ship, or from the shutting of doors, &c. It ought not to be exposed to a current of air. Nothing magnetic should be allowed near it. When the chronometer is on board a ship, free the stay, let the instrument swing horizontally, and place it securely, and so that it may be disturbed as little as possible during the voyage; using for deck-observations a common watch, which must be compared with the chronometer before and after any observation. In winding up a chronometer, turn it over gently; put the valve back, apply the key, turn it moderately, and avoid sudden jerks. A pocket chronometer must be held immovable in the one hand, whilst winding with the other, in order to avoid a circular motion, which may not only alter the rate, but injure the instrument. If a chronometer should happen to run down, or stop, it must, when wound up, have a quick circular motion in the plane of the dial to set it agoing. Never touch the hands to set the chronometer, but wait till the time arrives at which they point. Be regular in winding. Get an observation as soon as you leave a port, to ascertain if you have the correct difference from Greenwich time; and in case it should happen to stop, or to run down, during the passage, it may be corrected by lunar observations, by the method explained in pages 251, 252.

It has been found that chronometers gain by an increase of the density of the air, and lose by a decrease of the density. The firing of guns on board a vessel will sometimes alter the rate of going, unless the instrument be well suspended, or held in the hand during the firing. Any sudden jar will sometimes alter the rate. The imperfection of the oil used will, after some time, impair the instrument. The mechanism for correcting the changes in the temperature may not do it completely, and some error may arise from this source. Notwithstanding these various causes of error, it is wonderful to observe how accurately some of these chronometers perform their office.

The manner of using a chronometer in finding the longitude by means of observations of the moon's transits over the meridian, with a transit instrument, will be given in the Appendix to this work.

On a variation chart.

In the year 1700, Dr. Halley published a chart, in which the lines of the variation of the compass were drawn, for the purpose of determining the longitude by means of the observed variation; and, since that time, several charts of this kind have been published for the same purpose; but the method is not sufficiently accurate to be of any practical use. A variation chart is, however, useful, as a subject of scientific inquiry, and for the purpose of correcting a ship's course. The latest and by far the best work of this kind, is that of the Admiralty, published in 1859, and republished by E. & G. W. Blunt, in 1860. Every navigator should have it for daily use.

Digitized by Google

METHOD OF KEEPING
A SHIP'S RECKONING OR JOURNAL
AT SEA.

A SHIP'S RECKONING is that account, by which it can be known at any time where the ship is, and on what course or courses she must steer to gain her port. DEAD RECKONING is that account deduced from the ship's run from the last observation.

THE LOG-BOARD.

H.	K.	F.	*Courses.*	*Winds.*	*Lee-way.*	*Transactions.*
2	6		S. W.	N. E.		
4	5	5				
6	5			N. W. by W.		
8	5					Moderate gales
10	4	5	E. N. E.	N. W.		and fair weather.
12	4	5				At 8 A. M., saw
2	4	5				a ship to the
4	4	5				northward.
6	4	5				
8	5		S. W.	W. N. W.	1	No observation.
10	4	5				
12	4					

The daily occurrences on board a ship are marked on a board or slate, called the *log-board* or *log-slate*, kept in the steerage for that purpose, being usually divided into seven columns: the first contains the hours from noon to noon, being marked by some for every two hours, but usually for every single hour; in the second and third columns are the knots and fathoms the ship is found to run per hour, set against the hours when the log was hove. Some navigators do not divide the knot into ten fathoms, but into half-knots only, making the third column H. K. The fourth column contains the courses steered by compass; the fifth, the winds; the sixth, the lee-way;* and the seventh, the alteration of the sails, the business done aboard, and what other remarks the officer of the watch thinks proper to insert. For it should be observed, that it is usual to divide a ship's company into two parts, called the starboard and larboard watches, who do the duty of the ship for four hours and four hours, alternately, except from 4 to 8 P. M., which is divided into two watches. The remarks made on the log-board are daily copied into a book, called the LOG-BOOK, which is ruled like the log-board. This book contains an authentic record of the ship's transactions; and the persons who keep a reckoning, transcribe them into their *journals*, and thence make the necessary deductions relative to the ship's place, every day at noon; this operation is called working a *day's work*. While a ship is in port, the remarks entered in the Log-Book are called *harbor-work*, or *harbor-journal;* and the day is then estimated according to the civil computation, as on shore; that is, from midnight to midnight; but at sea, the day's work ending at noon is dated the same as the civil day, so that the day's work marked Monday begins on Sunday noon, and ends on Monday at noon; the day thus marked is called a *nautical day;* the first 12 hours being marked P. M., the latter A. M. There are various ways of keeping journals at sea, according to the different tastes of navigators. Some keep only an abstract of each day's transactions, specifying the weather, what ships or lands were seen,

* The cause of the lee-way, and manner of allowing for it, are explained in the following page.

Digitized by Google

accidents on board, the latitude, longitude, course, and run; these particulars being drawn from the ship's Log-Book. Others keep a full copy of the Log-Book, and the deductions drawn therefrom, arranged in proper columns; this is the most satisfactory method to those who may have occasion to inspect the Journal; and we have adopted it in the following, but shall give an abstract, at the end, conformable to the other method.

When a ship is about losing sight of the land, the bearing of some noted place (whose latitude and longitude are known) must be observed, and its distance estimated and marked on the Log-Book; this is called *taking a departure.* In working this first day's work, the calculation is to be made in the same manner as if the ship had sailed that distance from that place upon a course opposite to that bearing, and that course and distance are to be entered accordingly into the traverse table, after allowing for the variation.

To allow for the variation.

We have already taught the methods of finding the variation, which must be allowed on all courses steered, and on all bearings taken with the compass; *to the right hand, if the variation be east, but to the left hand, if west;* the observer being supposed to be placed in the centre of the compass, looking towards the point from which the variation is to be allowed.

EXAMPLES.

Courses by compass.	*Variation, in points.*	*True courses.*
N. E. by E.	2 W.	N. E. by N.
N. E.	1¼ E.	N. E. by E. ¼ E
N. W.	3 W.	W. by N.
S. E.	3 E.	S. by E.
S. S. W.	1½ W.	S. ½ W.
E. S. E.	1¼ W.	E. ¾ S.
S. W. ¼ W.	½ W.	S. W. ¼ S.
N. N. E. ¾ E.	1½ E.	N. E. ¼ E.

To find the lee-way, and allow for it.

The courses must likewise be corrected for lee-way; the nature of which may be thus explained:—When a ship sails upon a wind, in a fresh gale, that part of the wind which acts upon the hull and rigging, together with a considerable part of the force exerted on the sails, tends to drive her immediately from the direction of the wind, or, as it is termed, to leeward. But since the bow of a ship exposes less surface to the water than the side, the resistance will be less in the first case than in the second; the velocity, therefore, in the direction of her head, will, in most cases, be greater than the velocity in the direction of her side, and the ship's course will be between the two directions; and the angle contained between the course towards which the ship's head is directed, and the course she really describes through the water, is termed her *lee-way.* The quantity of lee-way to be allowed will depend upon a variety of circumstances; as the mould and trim of the ship; the quantity of sail she carries; her velocity through the water, &c.: hence no general rules can be laid down with accuracy that will determine the quantity of lee-way in all cases. The following have, however, been usually given by most writers on navigation:—

1. When a ship is close-hauled, with all her sails set, the water smooth, and a light breeze of wind, she is then supposed to make little or no lee-way.
2. When the top-gallant sails are handed, allow 1 point.
3. When under close-reefed topsails, allow 2 points.
4. When one topsail is handed, allow 2½ points.
5. When both topsails are handed, allow 3½ points.
6. When the fore-course is handed, allow 4 points.
7. When under the mainsail only, allow 5 points.
8. When under a balanced mizzen, allow 6 points.
9. When under bare poles, allow 7 points.

As these allowances depend entirely on the quantity of sail set, without regard to any other circumstance, it is evident that they can be considered only as probable

Digitized by Google

conjectures, and may indeed serve to work up the day's work of a Journal that has been neglected. But since the computation of a ship's way depends much upon the accuracy of this allowance, it would be proper for the officer of the watch to mark the lee-way on the log-board, in the column reserved for that purpose. The lee-way may be estimated by observing the angle which the wake of the ship makes with the point right astern, by means of a semicircle marked on the tafferel, and divided into points and quarters; by means of which the angle contained between the direction of the wake and the point of the compass directly astern, may be easily ascertained.

The lee-way, thus determined, is to be allowed on all courses *steered, to the right hand of the course steered, when the larboard tacks are aboard,** *but to the left hand, when the starboard tacks are aboard;* the person making the allowance being supposed to be looking towards the point of the compass the ship is sailing upon.

EXAMPLES.

Courses steered.	*Winds.*	*Lee-way.*	*True courses.*
N. W.	N. N. E.	1 point.	N. W. by W.
E. N. E.	North.	2	East.
E. S. E.	South.	1	E. by S.
W. by N.	N. by W.	½	W. ½ N.
E. N. E. ½ E.	S. E.	3	N. E. ½ N.

When the variation and lee-way are both to be allowed on a course, you may do it at once, by allowing their sum when they are both the same way, or their difference when the allowance is to be made in different ways, taking care to make the allowance in the same way as the greater quantity ought to be, whether it be the variation or lee-way.

EXAMPLE I.

A ship steers W. by N., with her larboard tacks aboard, and makes one point lee-way, there being two points westerly variation. Required the true course.

Lee-way to the right-hand.....	1 point.
Variation to the left	2 points.
Difference allowed to the left ..	1 point.

Whence the course is west.

EXAMPLE II.

A ship steers E. S. E., with her starboard tacks aboard, and makes two points lee-way, there being one point westerly variation. Required the true course.

Lee-way to the left...........	2 points.
Variation to the left...........	1 point.
Sum allowed to the left.......	3 points.

Whence the course is E. by N.

In a violent gale, with a head wind and heavy sea, when it would be dangerous to carry sail, it is usual to lie to under sufficient sail to prevent the vessel from rolling so much as to endanger the masts and rigging. When a ship is lying to, the tiller is put over to leeward, and when the ship has head-way, the rudder acts upon her to bring her to the wind; the ship then loses her way in the water, which ceasing to act on the rudder, her head falls off from the wind, and the sail which is set fills and gives her fresh way through the water, which acting on the rudder, brings her head again to the wind. Thus the ship is kept continually falling off and coming to. In this case, you must observe the points on which she comes up and falls off, and take the middle between the two points for the apparent course, from which allow the variation and lee-way, and you will obtain the true course.

EXAMPLE.

A ship, lying to under her mainsail, with her starboard tacks aboard, comes up E. by S., and falls off N. E. by E., there being one point westerly variation, and she makes 5 points lee-way. What course does she make good?

The middle between E. by S. and N. E. by E. is E. by N.; and by allowing 6 points to the left hand (viz. 5 for lee-way and 1 for variation) the true course will be obtained, N. by E.

* See the note. page 199.

Digitized by Google

To exercise the learner, we shall add the examples of correcting for variation and lee-way contained in the following table:—

THE TABLE.

Courses steered.	*Winds.*	*Lee-way points.*	*Variation points.*	*Courses corrected.*
N. W. ½ W.	N. N. E.	½	¾ W.	N. 5¾ W.
W.	N. N. W.	¾	¾ W.	S. 6½ W.
W. S. W.	S.	1	¾ W.	S. 6¼ W.
W.	S. S. W.	¾	¾ W.	W.
W. by N.	N. by W.	1¼	¾ W.	S. 7 W.
S. W.	W. N. W.	1½	¾ W.	S. 1¾ W.
S.	W. S. W.	¾	1¼ W.	S. S. E.
S. S. W.	W.	1	1¼ W.	S. ¼ E.
S. W.	N. W. by W.	½	1¼ W.	S. S. W. ¼ W.
W.	S. S. W.	1¾	1¼ W.	W. ½ N.
W. by N.	N. by W.	1	1¼ W.	W. S. W. ¾ W.
S.	E. S. E.	2	1¼ W.	S. ¾ W.
E. by S.	S. ½ E.	¾	1¼ W.	E. by N.
E. N. E.	N.	1¾	1¼ W.	E. N. E ½ E.
E.	N. by E.	¾	1¼ W.	E. ½ N.
E.	S.	0	1¼ W.	E. N. E ¾ E.
S	E. S. E.	½	1¾ W.	S. by E. ¼ E.
E. S. E.	N. E.	½	1¾ W.	E. ¾ S.
W. S. W.	S.	¾	1¾ W.	S. W. by W.
W. by N.	S. W. by S.	1	1¾ W.	W. ¼ N.
N. W.	W. S. W.	1	1¾ W.	N. W. ¾ W.
S.	W. S. W.	1	¾ E.	S. ¼ E.
N. by E.	N. W. by W.	¾	1 E.	N. N. E. ¾ E.
N. W. by N.	W. by S.	1¼	1 E.	N. ¾ W.
N. W. by W.	N. by E.	1½	1¼ E.	N. W. by W. ¼ W.
W. by S.	N. W. by N.	1¾	2¼ E.	W. ½ S.

If the ship has been acted upon by a current or a heave of the sea, you must allow the set and drift as a course and distance in the Traverse Table, as directed in page 125.

Having corrected the courses for lee-way and variation, and estimated the distances sailed, the latitude and longitude in at noon are to be found by either of the preceding methods of sailing. The latitude and longitude, thus calculated, are called the latitude and longitude by *dead-reckoning;* and if the real course and distance made good by the ship could be estimated accurately by the compass and log, nothing more would be necessary to determine the ship's place at any time; but by reason of the various accidents that attend a ship's way, such as heave of the sea, unknown currents, different rates of sailing between the times of heaving the log, sudden squalls, improper allowance for lee-way and variation, the latitude and longitude of the ship, as deduced from the reckoning, will frequently differ from the latitude and longitude by observation. In this case, it will be proper to re-examine the calculation, to see whether a just allowance has been made for lee-way, variation, bad steerage, drift of the sea, error of the log-line and glass, &c., since it will sometimes be found that a different and more probable estimate of some of these quantities will make the dead-reckoning agree more nearly with the observations. Before the method of finding the longitude by lunar observations was introduced, the mariner had no other observation to be depended on except his latitude, and it was then usual to make allowances for supposed errors in the courses and distances, so as to make the latitude by observation and dead-reckoning agree. The method of doing this consists in finding, by the difference of latitude by observation, and the departure by account, the corrected course, distance, and difference of latitude, by Case II. of Middle Latitude, or Mercator's Sailing, as in the following example:—

EXAMPLE.

Yesterday at noon we were in the latitude of 39° 18′ N., and by an observation at noon this day are in the latitude of 37° 48′ N.; our dead-reckoning gives 107 miles

Digitized by Google

southing and 64 miles westing. Required the course, distance, and difference of longitude.

With the difference of latitude by observation, 90 miles, (the difference of 37° 48′ and 39° 18′,) and the departure by dead-reckoning, 64 miles, I find by Case II. of Middle Latitude Sailing, the course nearly 35°, and the distance 110 miles; and with the middle latitude by observation, 38° 33′, and the departure, 64 miles, I find the difference of longitude to be 82 miles. If the middle latitude by dead-reckoning, 38° 24′, had been taken, the result would have been nearly the same.

If you have not had an observation for several days, and then find an error in the latitude by account, you may on these principles correct the latitude on the intermediate days, by saying, *As the sum of all the distances sailed, since the first observation, is to the whole error in the latitude, so is the sum of the distances sailed, from the time of taking the first observation to the noon of any particular day, to the correction of the latitude by dead-reckoning on that day, southerly if the last latitude by observation is south of the latitude by dead-reckoning, otherwise northerly.* Thus, if the latitudes by dead-reckoning at noon, on four successive days, were 41° 0′, 41° 30′, 42° 0′, 43° 0′, the latitude by observation on the first day 41° 0′, and on the last day 43° 15′, differing 15 miles from the latitude by account; the distances sailed by the log, on the three days respectively, 30, 90, and 105 miles; we must say, As the whole sum of the distances, 225 miles, is to the error of the latitude, 15 miles, so is the first distance, 30, to the correction of the second latitude, 2′, and so is the sum of 30 and 90 ($=120$) to the correction of the third latitude, 8′; so that the corrected latitudes will be 41° 0′, 41° 30′ + 2′ = 41° 32′, 42° 0′ + 8′ = 42° 8′ and 43° 15′, and the corrected differences of latitude on the successive days will be 32′, 36′, and 67′, with which and the departure by dead-reckoning, the corrected courses, distances, &c., on each day, may be found, if thought necessary; but as the corrected longitude is not sensibly altered by any of these corrections, it appears to be in general wholly unnecessary to make any alteration in the Journal on this account. But if it be thought proper to notice these corrections in plotting off the track of a ship, it will be necessary first to plot off the courses by dead-reckoning, and then to place the points arrived at, at the end of each day, as much to the north or south of the places by dead-reckoning as will make the latitudes of those points agree with the corrected latitudes found by the above rule.

The latitude and longitude being found by the preceding methods, we may thence determine the bearing and distance of the place of destination; but when the mariner is fearful that his longitude by account is inaccurate, and he has no lunar observations or chronometer to correct it, he must get into the latitude of the place, and (if possible) run east or west, according to his situation and the prevailing state of the winds.

We have now given all the rules necessary for working a day's work, and, for the convenience of the learner, (to enable him to refer to them easily,) we have here collected them in the eight following articles:—

Rules for working a day's work.

1. Correct the several courses sailed * for variation and lee-way, and enter them in a traverse table, and opposite to each course place the distance run on that course, found by summing up the knots and fathoms sailed by the ship on that course. Find in Table I. or II. the difference of latitude and departure corresponding to each course and distance, and set them in their respective columns; then the difference between the sums of the northings and southings will be the difference of latitude made good, of the same name with the greater; and the difference between the sums of the eastings and westings will be the departure made good, of the same name with the greater quantity.

2. Seek in Table I. or II. until the above difference of latitude and the departure are found together in their respective columns; opposite to these will be the distance made good, and at the top or bottom of the page, according as the departure is less or greater than the difference of latitude, will be found the course.

3. If the latitude from which the ship's departure is taken, or yesterday's latitude, be of the same name as the difference of latitude, add them together; but if of different names, take their difference; the sum or remainder will be the present latitude, of the same name as the greater.

* The set and drift of a current (if there be any) is to be reckoned as a course and distance, and on the first day after losing sight of the land, the bearing and distance of it are to be taken into account.

Digitized by Google

4. Find the middle latitude between the latitude of yesterday and this day which take as a course in Table II., and seek for the departure in the column of difference of latitude; then will the distance corresponding be the difference of longitude, of the same name as the departure.

5. If the longitude in yesterday be of the same name as the difference of longitude, add them together; but if of different names, take their difference; the sum or remainder will be the longitude in, of the same name as the greater.

6. If a lunar observation were taken at any time of the day, you must find, by the above method, the difference of longitude made since taking the observation for regulating the watch, and thence the longitude in at noon by that observation, and enter it in the Journal as the longitude by observation.

Whenever it is possible to obtain satisfactory observations, lunar distances should be taken.

7. If you have a chronometer, regulated for mean time at Greenwich, and you can find, by observation, the mean time at the ship, the difference between these two times will be the longitude of the ship at the time of observation, as shown by the chronometer. This longitude, reduced to noon, by means of the log, may also be entered in the Journal.

If navigators would reject the absurd mode of reckoning by the SEA-DAY, *and adopt* ASTRONOMICAL *time, it would lessen their labor and tend to much greater accuracy in their daily works.* Why cannot this be done?

8. Find on a general chart the spot corresponding to the latitude and longitude by observation, and that place will represent the situation of the ship, whence the bearing and distance of the intended port may be found. The same may be obtained by middle latitude sailing, by inspection of Table II., thus: Find the middle latitude between the place of the ship and the proposed place, and seek for that latitude as a course in Table II., and find, in the corresponding page of the table, the difference of longitude (between the ship and the proposed place) in the distance column, opposite to which, in the latitude column, will be the departure. Seek in Table II. for this departure and the difference of latitude (between the ship and the proposed place) till they are found to agree; corresponding thereto will be the bearing and distance required. If the magnetic bearing be required, the variation must be allowed on the true bearing; to the right hand if the variation is westerly, or to the left hand if easterly.

9. When the latitude, by account, is uncertain, the known position of the ship "on a line of bearing" may be of very great importance. In this case the mode of proceeding is shown on page 205, or in Sumner's work.

We shall now proceed to exemplify the above rules; first by a few examples of separate days' works, and then by a Journal from Boston to Madeira, kept in the usual form.

Digitized by Google

EXAMPLE I.

Yesterday, at noon, we were in the latitude of 48° 21′ N., and the longitude of 36° 28′ W., and have sailed till this day at noon, as per log-board. Required the course and distance made good, with the latitude and longitude in.

LOG-BOARD.

H.	K.	F.	*Courses.*	*Winds.*	*Lee-way.*	*Remarks*
2	6		S. W. by W. ¾ W.	N.		These 24 hours, moderate gales
4	5	5				and cloudy weather.
6	5			N. W.		At 4 P. M., spoke ship Washing-
8	5					ton, from New York, bound to
10	3	6	S. W. ¾ W.			Cork.
12	3	4				
2	3	4				
4	4	5				
6	4	6				At 6 A. M., stowed the anchors,
8	5		S. W. ¼ S.	W.N.W.		and unbent the cables, and coiled
10	4	5				them between decks.
12	4					Variation 2¼ points westerly.*

TRAVERSE TABLE.

Courses.	*Dist.*	N.	S.	E.	W.
S. W. ¼ S.	43		33.2		27.3
S. S. W. ¼ W.	39		34.4		18.4
S. by W. ½ W.	27		25.8		7.8
	Diff. Latitude		93.4	Dep.	53.5

By examining the log-board, it appears that the ship goes large, and makes no lee-way; therefore, by allowing the variation on each of the courses, they will stand as in the adjoined Traverse Table. Then the distances marked on the log-board must be summed up and doubled, because they are marked only for every two hours.† In allowing for the fathoms, we must reckon 10 to a mile; and when the tenths are above 5, we must add 1 mile to the distance. Having found the distances, we must find the corresponding differences of latitude and departures, in Table I. or II., and then, with the whole difference of latitude and departure, we must find the course and distance made good, and the difference of longitude, by Case II. of Middle Latitude Sailing.

In the present example, the difference of latitude is............93′ =	1°	33′	S
Yesterday's latitude..	48	21	N.
The difference is the latitude in....................................	46	48	N.
Sum of the latitudes..	95	9	
Middle latitude	47	34	

With the difference of latitude made good, 93.4 S., and the departure, 53.5 W., we must enter Table II., and we shall find they correspond nearly to a course of S. 30° W., and distance 108 miles. Then, with the middle latitude 47° 34′, or 48°, we must enter Table II., and we shall find the departure 53.5 in the latitude column; opposite to which, in the distance column, is the

Difference of longitude.......................................80′ =	1°	20′	W.
Longitude left	36	28	W
Sum is the longitude in..	37	48	W

* As these examples were given only to illustrate the rules, we have not been attentive to mark the true variation.

† In long voyages, it is customary to mark the log-board every hour; in that case, the distances marked on the log, being summed up, will be the true distance sailed.

Digitized by Google

EXAMPLE II.

Yesterday, at noon, we were in the latitude of 35° 46′ N., and the ongitude of 17° 42′ W., and have sailed till this noon as per log-board. Required the latitude and ongitude in, and the bearing and distance of Cape St. Vincent.

LOG-BOARD.

H.	K.	F.	*Courses.*	*Winds.*	*Lee-way.*	*Remarks.*
1	6	6	S. by E. ½ E.	S. W. ½ W.	1½	These 24 hours, moderate gales and clear weather
2	6	6				
3	5	8				
4	5	8				
5	5	8				
6	5	8				
7	5	8				
8	5	8				
9	5		S. S. E.	S. W.	1½	
10	5					
11	5	2				At 8 A. M., saw a ship to windward, steering east.
12	5	2				
1	5	3				
2	5	3				
3	5	5	S. S. E. ½ E.	S. W. ½ S.	1½	
4	5	5				
5	5	5				
6	5	5				
7	5	5				
8	5	5				
9	5	6	S. E. by S.	S. W. by S.	1½	
10	5	6				
11	5	4				
12	5	4				Variation, ½ point easterly.

TRAVERSE TABLE.

Courses.	*Dist.*	N.	S.	E.	W.
S. S. E. ¾ E.	48		41.2	24.7	
S. E. ¾ S.	31		24.9	18.5	
S. E. ¼ S.	33		24.5	22.2	
S. E. ¼ E.	22		14.8	16.3	
	Diff. Lat.		105.4	81.7 Dep.	

The courses being corrected for lee-way and variation, and the distances summed up, (but not doubled, since the log-board is marked for every hour,) will stand as in the adjoined traverse table. Hence, the difference of latitude made good is 105.4 S., and the departure 81.7 E.; consequently the course is S. 38° E., and the distance 133 miles nearly.

Latitude left..................	35° 46′	N.
Difference of latitude.........	1 45	S.
Latitude in....................	34 1	N.
Sum of the latitudes...........	69 47	
Middle latitude	34 53	

With the middle latitude 34° 53′, or 35°, and the departure 81.7, the diff. of long is found to be 100 miles = 1° 40′ E.

Longitude left...............	17 42	W
Longitude in.................	16 2	W

To find the bearing and distance of Cape St. Vincent.

Latitude in.........	34° 1′ N.	Mer. parts	2173	Longitude in....	16° 2′ W.
Cape St. Vincent's lat.	37 3 N.	Mer. parts	2396	Cape St. Vin. long.	9 2 W.
Difference of latitude	3° 2′ = 182′	Mer. diff. lat.	223	Diff. longitude...	7° 0′ = 420′

BY LOGARITHMS.

To find the bearing.

As mer. diff. latitude 223...log.		2.34830
Is to radius .... 45°......		10.00000
So is diff. longitude. 420...log.		2.62325
To tangent course 62° 02′		10.27495

To find the distance.

As radius	45°	.....10.00000
Is to prop. diff. lat.	182	..... 2.26007
So is secant course	62° 02′	.....10.32887
To the distance...	388.1	..... 2.58894

Hence, the bearing of Cape St. Vincent is N. 62° 02′ E., and distance 388.1 miles.

Digitized by Google

EXAMPLE III.

Suppose that, at the end of the sea-day, March 10, 1864, we were in the latitude of 43° 34′ N., and the longitude of 50° E., and have sailed till next noon, as per log-board Required the latitude and longitude in, and the variation of the compass, having taken for this purpose the observation marked on the log-board.

LOG-BOARD.

H.	K.	F.	*Courses.*	*Winds.*	*Lee-way.*	*Remarks.*
2	4	5	W. S. W.	South.		These 24 hours, moderate gales; found a small current setting N. E., at the rate of 1 mile in 4 hours.
4	4	5				
6	4	5				
8	4					
10	4					
12	4					
2	3	5				
4	3	5	S. W. by W.	S. by E.		
6	3					At 8 A. M., sun's magnetic azimuth N., 125° 19′ E.; altitude of ☉'s lower limb, 18° 43′; correction for dip and semidiameter, 12′ additive.
8	3					
10	3					
12	3	5				

In calculating the variation from the above observation, it is necessary to find the declination and latitude at the time of observation. The former, at noon ending the sea-day, March 11, 1864, was 3° 29′ S. by Table IV.; the correction for the longitude 50° E. is + 3′ 13″, and for the time from noon 4^h is + 3′ 51″; therefore the whole correction is nearly 7′, which, being added to 3° 29′ gives the declination at the time of observation 3° 36′ S.; consequently the polar distance 93° 36′. To find the latitude, we must see by the log-board what courses and distances the ship has sailed, from noon to the time of observation, at 8 A. M., viz.: W.S.W. 58 miles, and S.W. by W. 19 miles; the current setting in the same time N.E 5 miles; these courses must be corrected for one point westerly variation, which is found to be nearly its value, by a rough calculation made with the latitude in, the preceding noon; and by arranging these courses and distances in a traverse table, we find that the difference of latitude made good, at 8 A. M., is about 41 miles; consequently the latitude in, at the time of observation, is nearly 42° 53′ N.; the observed altitude of the sun's lower limb is 18° 43′; the correction for dip and semidiameter + 12′, and the refraction by Table XII.—3′ nearly; consequently the sun's correct altitude is 18° 52′. With these data, the true azimuth is calculated, as in page 160.

Polar distance..........	93° 36′		
Latitude..............	42 53	...........Secant	0.13505
Altitude..............	18 52	...........Secant	0.02398
Sum..................	155 21		
Half-sum..............	77 41	...........Cosine	9.32902
Polar distance..........	93° 36		
Remainder............	15 55	...........Cosine	9.98302
		Sum	19.47107
			9.73554
Half-sum is log cosine.......	57° 3′		
	2		
True azimuth.............N.	114 6 E.		
Magnetic azimuth.........N.	125 19 E.		
Variation..................	11 13 W., or nearly 1 point.		

TRAVERSE TABLE.

Courses.	*Dist.*	N.	S.	E.	W.
S. W. by W.	58		32.2		48.2
S. W.	32		22.6		22.6
N. E. by N.	6	5.0		3.3	
		5.0	54.8	3.3	70.8
			5.0		3.3
	Diff. Lat.		49.8	Dep.	67.5

The variation being allowed on all the courses, and on the set of the current, and the distances being summed up, the traverse table will be as adjoined; and the difference of latitude made good = 49.8 S., departure = 67.5 W. Hence the course made good is S. 53¼° W., and the distance = 84 miles. Subtracting the difference of latitude 50′, from latitude left 43° 34′, there remains the latitude in 42° 44′ N. Hence we have the middle latitude 43° 9′, with which, and the departure 67.5, we find the difference of longitude to be 92′, or 1° 32′ W., nearly; and by subtracting it from the longitude left, 50° E., we get the longitude in 48° 28′ E.

Digitized by Google

EXAMPLE IV.

Yesterday, at noon, we were in the latitude of 40° 19′ N., and in the longitude of 67° 58′ W., and have sailed till this noon as per log-book. Required the bearing and distance of Cape Cod.

LOG-BOARD.

H.	K.	F.	*Courses.*	*Winds.*	*Lee-way.*	*Remarks.*
1	1		W. N. W.	North.	1	First part of these 24 hours, light breezes and fine weather; latter part, pleasant gales and cloudy.
2	1					
3	1					
4	1					
5	2	5				
6	3					
7	1	5				
8	1	5				
9	1	5				
10	1					
11	1		N. W.	N. N. E.	1	Saw great quantities of Gulf weed and rock weed.
12	1					
1	2	5	N. W. ½ N.	N. E. ½ E.	1	
2	2	5				
3	2	5				
4	2	5				
5	3		N N. W.	N. E. by E.	0	At 7 A. M., water discolored, sounded no bottom.
6	3					
7	3					
8	3					
9	4					
10	4					
11	4	5		E. N. E.		Latitude, by observation, 40° 50′ N.
12	4	5				Variation ¾ of a point W.

TRAVERSE TABLE.

Courses.	*Dist.*	N.	S.	E.	W.
W. ¼ N.	15	0.7			15.0
N. W. by W. ¾ W.	2	0.9			1.8
N. W. by W. ¼ W.	10	5.1			8.6
N. N. W. ¾ W.	29	24.9			14.9
	Diff. Lat.	31.6			Dep. 40.3

The distances are to be summed up, and marked in the traverse table without doubling, because the log-board is marked for every hour. By working this day's work like the others, we find the difference of latitude made good = 31.6 N., and the departure 40.3 W.; hence the course N. 52° W. nearly, and distance 51 miles.

Latitude left	40° 19′	N.
Difference of latitude	32	N.
Latitude in by dead-reckoning	40 51	N.
Sum of latitudes	81 10	
Middle latitude	40 35	

With the middle latitude 40½°, and the departure 40.3, we find the difference of longitude is............ 0° 53′ W.
Longitude left.............. 67 58 W.
Longitude in............... 68 51 W

To find the bearing and distance of Cape Cod.

Latitude in by obser.	40° 50′ N.
Latitude of Cape Cod	42 3 N.
Difference of latitude	1 13 = 73 miles.
Middle latitude......	41 26½

Long. in by D. R. ...	68° 51′ W.
Long. of Cape Cod ..	70 4 W.
Diff. of longitude	1 13 = 73 miles.

With the difference of longitude, 73 miles, and the middle latitude, 41° 26½′ or 41½°, we find the departure, 54.6 nearly; with which, and the difference of latitude 73 miles, the bearing of Cape Cod is found to be N. 37° W., distant 91 miles.

Digitized by Google

JOURNAL

OF A VOYAGE FROM BOSTON TO MADEIRA.

H.	K.	F.	*Courses.*	*Winds.*	*Lee-way.*	**Remarks** *on board, Friday, March* 25, 1864.
1						At noon, got under way, with a fine breeze from the N. W.
2						
3						
4						Got a good bearing of the sun at noon, and found the *variation and local attraction* of the *standard compass* 8° W. Ship heading West.
5						
6						
7						
8						
9	6	5	E. by S.	N. W.		At 8 P. M., Cape Cod light-house bore S. by E. ¾ E., distant 14 miles; from which I take my departure.
10	6	5				
11	6	5				
12	6	5				
1	6					
2	6					
3	6					
4	6					
5	6	5				
6	6	5				Thermo at noon.................41°
7	6			North.		do. at midnight...............35°
8	6					Barom. at noon..................29.90
9	6					do. at midnight...............29.78
10	6					
11	7					
12	7					Variation ¾ of a point westerly.

Course.	*Dist.*	*Diff. Lat.*	*Dep.*	*Lat. by D. R.*	*Lat. by Obs.*	*Diff. Long.*	*Longitude in, by D. R.*	*Lun. Obs.*	*Chron.*
N. 85° 34′ E.	95	N. 7	E. 94	N. 42° 10′		E. 2° 7′	W. 67° 57′		W. 67° 58′

TRAVERSE TABLE.

Courses.	*Dist.*	N.	S.	E.	W.
N.N.W. ½ W.	14	12.3			6.6
E. ¼ S.	101		5.0	100.9	
		12.3	5.0	100.9	6.6
		5.0		6.6	
		Diff. Lat. 7.3		Dep. 94.3	

Cape Cod bearing from the ship S. by E. ¾ E., distant 14 miles, is the same as if the ship had sailed from it 14 miles, upon the opposite, or N. by W. ¾ W. point of the compass; and, allowing for the variation, it becomes N. N. W. ½ W.; this, and the distance 14 miles, are to be set in the traverse table, as the first course and distance.

The ship sailed all day upon an E. by S. course by compass, which, by allowing the variation, is E. ¼ S. The whole distance sailed (or the sum of all the distances) is 101 miles. With these courses and distances, we find the corresponding differences of latitude and departures; and by subtracting the southing from the northing, and the westing from the easting, we find that the difference of latitude made good is 7.3 N., and the departure 94.3 E., which correspond to a course N. 85° 34′ E., and distance 95 miles.

Latitude sailed from, or Cape Cod's lat....	42° 3′	N.
Difference of latitude........................	0 7	N.
Latitude in......................................	42 10	N.
Sum of latitudes..............................	84 13	
Middle latitude	42 7	

Then, with the middle latitude 42° as a course, we must enter Table II., and against the departure 94.3, (or 94.4, which is the nearest tabular number,) found in the latitude column, is 127 = the difference of longitude in the distance column.

Longitude from, or Cape Cod's longitude	70° 4′	W.
Difference of longitude......................	2 7	E.
Longitude in....................................	67 57	W

To find the bearing and distance of Funchal.

Latitude in	42° 10′ N.	Meridional parts.......	2795	Longitude in.........	67° 57′ W
Funchal's latitude ..	32 38 N.	Meridional parts.......	2073	Funchal's longitude..	16 54 W
Difference of latitude	9 38	Meridional diff. latitude	722	Difference of longitude	51 3
	60				60
In miles	578			In miles.............	3063

With the meridional difference of latitude 722 miles, and difference of longitude 3063 miles, the bearing is found to be S. 76° 44′ E.; and with this bearing taken as a course, and the proper difference of latitude 578 miles, the distance is found to be 2493 miles, by Case I. of Mercator's Sailing.

Digitized by Google

H.	K.	F.	*Courses.*	*Winds.*	*Lee-way.*	REMARKS *on board, Saturday, March* 26, 1864.
1	7		E. by S.	N. by E.		Fresh gales and pleasant weather.
2	7					
3	7					Saw a number of fishing-vessels to the southward.
4	7					
5	7					
6	7					
7	7		E. by S. ½ S.	N. N. E.		At noon observed the altitude of the
8	7					sun's lower limb, bearing south.. 50° 35′
9	7					Add for semidiameter, dip, &c.... 0 12 [Refraction, being small, is neglected.]
10	7					Correct altitude.................. 50 47
11	7					Subtract from..................... 90 00
12	7					
1	7		E. S. E.			☉'s zenith distance .... 39 13 N.
2	7					☉'s correct declination........... 2 30 N.
3	6	6				Latitude by observation......... 41 43 N.
4	6	6				
5	6	4				
6	6	4				Took a double altitude of the sun at 10^h and
7	6	4				11^h 15^m, and found, by the *first method*, on
8	6	4				page 180, the latitude at the time of the
9	6	6				second observation to be 41° 44′ N.
10	6	6				
11	6	5				
12	6	5				Variation ¾ of a point westerly.

Course.	*Dist.*	*Diff. Lat.*	*Dep.*	*Lat. by D. R.*	*Lat. by Obs.*	*Diff. Long.*	*Longitude in, by* D. R.	*Lun. Obs.*	*Chron.*
S. 80° 15′ E.	162	S. 27	E. 160	N. 41° 43′	N. 41° 43′	E. 3° 35′	W. 64° 22′		W. 64° 20′

TRAVERSE TABLE.

Courses.	*Dist.*	N.	S.	E.	W.
E. ½ S.	42		2.1	41.9	
E. ¾ S.	42		6.2	41.5	
E.S.E. ¾ E.	79		19.2	76.6	
	Diff. Lat.		27.5	160.0 Dep.	

The variation being allowed on each course, and the distances summed up, they will stand as in the adjoining traverse table; hence, by means of Table I., we find the difference of latitude 27.5, and the departure 160.0, which correspond to the course of nearly S. 80° 15′ E., and the distance 162 miles.

Yesterday's latitude	42° 10′ N.
Difference of latitude	27 S.
Latitude in	41 43 N.
Sum of latitudes......................	83 53
Middle latitude.......................	41 56

With the middle latitude 41° 56′, or 42°, as a course, we must enter Table II., and seek for the departure 160.0 in the latitude column; the nearest number to which is 159.8, corresponding to the distance 215, which is therefore the difference of longitude, equal to.... 3° 35′ E.

Yesterday's longitude	67 57 W.
Longitude in	64 22 W.

To find the bearing and distance of Funchal.

Latitude in.........	41° 43′ N.	Meridional parts......	2759	Longitude in.........	64° 22′ W.
Funchal's latitude..	32 38 N.	Meridional parts......	2073	Funchal's longitude..	16 54 W.
Difference of latitude	9 5	Meridional diff. latitude	686	Difference of longitude	47 28
	60				60
In miles	545			In miles............	2848

By Case I. of Mercator's Sailing, we find the bearing of Funchal to be S. 76° 27′ E., and its distance 2326 miles.

When the sun was upon the meridian, the altitude of his lower limb was observed, and found to be 50° 31′, to which add 12′ for the semidiameter, parallax, and the dip of the horizon; the refraction (given in Table XII.) for this altitude, being small, is neglected; hence the correct central altitude was 50° 43′, which, being subtracted from 90°, leaves the zenith distance 39° 17′, which must be called north, because the sun bore south when on the meridian, then, in Table IV., we find the sun's declination at noon at Greenwich = 2° 26′ N.; to this add the correction 4′ taken from Table V., corresponding to the ship's longitude; the sum is 2° 30′ N. = the correct declination; and since the declination and zenith distance are both north, we must add them together, and the sum will be the latitude by observation = 41° 43′ N., which agrees with the latitude by account.

Digitized by Google

H.	K.	F.	*Courses.*	*Winds*	*Lee-way.*
1	7		E. S. E.	N. by E.	
2	7				
3	8				
4	8				
5	8				
6	8				
7	8				
8	8				
9	8				
10	8				
11	8				
12	8				
1	8	6		N. N. E.	
2	8	6			
3	8	6			
4	8	6			
5	8	6			
6	8	6			
7	8	6			
8	8	6			
9	8	1			
10	7	1			
11	7				
12	7			N. E. by N.	

REMARKS *on board, Sunday, March* 27, 1864.

All these 24 hours, fresh breezes and clear.

Observed the distance of the sun from the moon. The longitude at noon, by the *first* method, on page 231, was found to be 60° 16′ W.

Meridional alt. sun's lower limb..	51° 55′
Add for semidiameter, dip, &c...	12
Sun's correct altitude...........	52 07
Subtract from..................	90 00
Sun's zenith distance...........	37 53 N.
Sun's correct declination........	2 53 N.
Latitude observed..............	40 46 N.

Thermometer at noon...............47°
do. at midnight...........45°
Barometer at noon................29.70
do. at midnight 29.62

Variation ¾ of a point westerly, per amplitude.

Course.	*Dist.*	*Diff. Lat.*	*Dep.*	*Lat. by D. R.*	*Lat. by Obs.*	*Diff. Long.*	*Longitude in, by D. R.*	*Lun. Obs.*	*Chron.*
E.S.E. ¾ E.	192	S. 47	E. 186	N. 40° 56′	N. 40° 46′	E. 4° 8′	W. 60° 14′	☉ ☽ 60° 16′	W. 60° 13′

TRAVERSE TABLE.

Course.	*Dist.*	N.	S.	E.	W.
E. S.E. ¾ E.	192	Diff. Lat. 46.7		186.2 Dep.	

The ship sailed all day upon the same course, which, being corrected for the variation, is E. S. E. ¾ E.; the whole distance sailed is 192 miles, and the difference of latitude is 47 miles =.................. 0° 47′ S.

Yesterday's latitude	41 43 N.
Latitude by daily reckoning..	40 56 N.

So that the latitude by account differs 10 miles from the latitude by observation.

Latitude yesterday by observation	41° 43′ N.
Latitude by observation this day	40 46 N.
Difference of lat. by observation..	57
Sum of latitudes	82 29
Middle latitude	41 14

With the middle latitude 41° 14′ as a course, and the departure 186.2 as difference of latitude, we find the corresponding distance 248, which is equal to the difference of longitude.................... 4° 8′ E.

Yesterday's longitude..........	64 22 W.
Longitude in	60 14 W.

To find the bearing and distance of Funchal.

Latitude in......	40° 46′ N.	Meridional parts	2683	Longitude in......	60° 14′ W.
Funchal's latitude	32 38 N.	Meridional parts	2073	Funchal's longitude	16 54 W.
Diff. of latitude..	8 8	Mer. diff. lat...	610	Difference longitude	43 20
	60				60
In miles	488			In miles	2600

With the meridional difference of latitude and difference of longitude, the bearing is found to be S. 76° 48′ E.; with that, and the proper difference of latitude, the distance is found to be 2137 miles,* by Case I. Mercator.

* If the course was calculated to seconds, and the meridional parts taken to one or two places of decimals, it would sometimes make a difference of a few miles in the calculated distance. We may here remark, that, as this Journal is only designed to exemplify the rules of navigation, we have not endeavored to give the true variation.

Digitized by Google

H.	K.	F.	Courses.	Winds.	Lee-way.	REMARKS on board, Monday, March 28, 1864.
1	7		S. E. by E.	N.E. by E.	1	Fresh gales, with rain.
2	7					At 4 A. M., spoke the ship Franklin, from
3	6	6				Philadelphia, bound to Lisbon.
4	6	6				At noon, observed meridian alti-
5	6					tude ☉'s lower limb..........54° 00′
6	6					Add for semidiameter, &c........ 0 12
7	5	4				
8	5	4				☉'s correct altitude............54 12
9	5	6	S. E.	E. N. E.	1	Subtract from.................90 00
10	5	6				
11	5	6				☉'s zenith distance............35 48 N.
12	5	6				☉'s correct declination........ 3 16 N.
1	5	3				
2	5	3				Latitude observed..............39 4 N.
3	5	5				
4	5	5				By an altitude of the pole star taken at 9h
5	6		S. E. by S.	E. by N.	1	P. M., the latitude was found, by the rule
6	6					on page 206, to be 38° 32′ N.
7	6					Thermo. at noon..................48°
8	6					do. at midnight.............44°
9	6					Barom. at noon..................29.60
10	6					do. at midnight..............29.88
11	5					
12	5					Variation, ¾ of a point westerly.

Course.	Dist.	Diff. Lat.	Dep.	Lat. by D. R.	Lat. by Obs.	Diff. Long.	Longitude in, by D. R.	Lun. Obs.	Chron.
S. 42° 29′ E.	138	S. 102	E. 93	N. 39° 4′	N. 39° 4′	E. 2° 2′	W. 58° 12′		W. 58° 14′

TRAVERSE TABLE.

Courses.	Dist.	N.	S.	E.	W.
S. E. ¾ E.	50		29.8	40.2	
S. E. ¼ S.	44		32.6	29.5	
S.S.E. ¾ E.	46		39.5	23.6	
	Diff. Lat.		101.9	93.3 Dep.	

The lee-way and variation being allowed on the courses, they will stand as in the adjoined traverse table. Then, with the difference of latitude and departure, the course is found to be S. 42° 29′ E., and the distance 138 miles.

Yesterday's latitude	40° 46′	N.
Difference of latitude 102′ =	1 42	S.
Latitude in	39 4	N.
Sum of latitudes..............	79 50	
Middle latitude...............	39 55	

With the middle latitude 39° 55′, or 40°, as a course, and the departure 93.3, taken as difference of lat., the difference of long. is found to be 122 miles.. = 2° 2′ E.
Yesterday's longitude........ 60 14 W
Longitude in................ 58 12 W.

The course made good each day is marked in the Journal to degrees and minutes, as it was calculated by logarithms; but for practical purposes, it is sufficiently exact to find it to the nearest degree, by means of Table II.

To find the bearing and distance of Funchal.

[By Case I. Middle Latitude Sailing.]

Latitude in..........	39° 4′ N.	Longitude in..........	58° 12′ W
Funchal's latitude....	32 38 N.	Funchal's longitude....	16 54 W
Difference of latitude.	6 26 = 386 miles.	Difference of longitude	41 18
			60
Sum of latitudes......	71 42		
Middle latitude.......	35 51	In miles.............	2478

With the middle latitude 35° 51′, or 36°, as a course, and the difference of longitude 2478, as a distance, we may calculate the departure; with that and the difference of latitude, we can find the distance and course, by Case I. of Middle Latitude Sailing.

Digitized by Google

H.	K.	F.	*Courses.*	*Winds.*	*Lee-way.*
1	4		South.	E. S. E.	1
2	4				
3	4				
4	4				
5	4				
6	4				
7	4				
8	4				
9	4				
10	4				
11	4				
12	4				
1	3	6	S. ½ E.	E. by S. ½ S.	1½
2	3	6			
3	3	4			
4	3	4			
5	3				
6	3				
7	3				
8	3				
9	3				
10	3				
11	3				
12	3				

Remarks on board, *Tuesday, March* 29, 1864

These 24 hours, moderate, pleasant weather

Mer. altitude sun's lower limb...	55° 40′
Add for semidiameter, dip, &c...	0 12
☉'s correct altitude......	55 52
Subtract from..................	90 00
☉'s zenith distance.............	34 8 N.
☉'s correct declination.........	3 40 N.
Latitude observed..............	37 48 N.

Took a lunar observation by observing the distance of the moon from the sun. The longitude at noon, calculated by the first method, on page 231, was 58° 17′ W. Noting the time by *chronometer* when the distance was taken, and calculating the time by the rules on page 209 or 210, from the observed altitude of the sun, the longitude by chronometer was found to be 58° 13′ W. at noon.

Variation, 1 point westerly.

Course.	*Dist.*	*Diff. Lat.*	*Dep.*	*Lat. by D. R.*	*Lat. by Obs.*	*Diff. Long.*	*Longitude in, by D. R.*	*Lun. Obs.*	*Chron.*
South.	86	S. 86	0	N. 37° 38′	N. 37° 48′	0	W. 58° 12′	W. 58° 17′	W. 58° 13′

TRAVERSE TABLE.

Course.	*Dist.*	N.	S.	E.	W.
South.	86		86.0		
			86.0 Diff. Lat.		

The lee-way and variation being allowed on both courses, they become south; the whole distance sailed, 86 miles, is, therefore, the difference of latitude by account, the departure being nothing; consequently, the ship is in the same longitude as yesterday.

Yesterday's latitude........................		39° 4′ N.
Difference of latitude..................	86 =	1 26 S.
Latitude in, by dead-reckoning		37 38 N.

The latitude by observation was 37° 48′ N.; differing 10 miles from the account.

To find the bearing and distance of Funchal.

Latitude in	37° 48′ N.	Meridional parts	2453	Longitude in......	58° 12′ W.
Funchal's latitude	32 38 N.	Meridional parts	2073	Funchal's longitude	16 54 W
Diff. of latitude..	5 10	Mer. diff. lat....	380	Diff. of longitude ..	41 18
	60				60
In miles	310			In miles.........	2478

Hence the bearing is found to be S. 81° 17′ E., and the distance 2046 miles, by Case I. of Mercator's Sailing; and the same may be found by Middle Latitude, which is the most exact method when the two latitudes differ but little; and it is the way in which the calculation will be made in the rest of the Journal. If great accuracy were required, we might correct the middle latitudes by the numbers in page 76 but we have not thought it to be necessary in the present Journal.

Digitized by Google

H.	K.	F.	*Courses.*	*Winds.*	*Lee-way.*	REMARKS *on board, Wednesday, March* 30, 1864.
1	3		East.	N. N. E.	3	These 24 hours, fresh gales and squally.
2	3					Handed the fore and main courses.
3	3					
4	3					
5	Lay to; up, S. E. by E.;				5	
6	off, S. E. by S. Drift, 1½					
7	miles per hour.					
8						
9	Up, S.; off, S. W. Drift,				5	
10	1½ miles per hour.					
11						At midnight, more moderate. Wore ship,
12						and set the courses.
1	2	5	E. by N.	S. E. by S.	1½	
2	2	5				
3	3					
4	3					
5	3	5				At 6 A. M., set the topsails close-reefed.
6	3	5				
7	2	5				Thermometer at noon .... 53°
8	2	5				do. at midnight .... 50°
9	2	5				Barometer at noon 29.00
10	2	5				do. at midnight 28.22
11	2					
12	2					Variation, 1 point westerly.

Course.	*Dist.*	*Diff. Lat.*	*Dep.*	*Lat. by D. R.*	*Lat. by Obs.*	*Diff. Long.*	*Longitude in, by D. R.*	*Lun. Obs.*	*Chron.*
N. 76° 17′ E.	31	N. 7	E. 30	N. 37° 55′		E. 0° 38′	W. 57° 34′		57° 36′

TRAVERSE TABLE.

Courses.	*Dist.*	N.	S.	E.	W.
E. S. E.	12		4.6	11.1	
South.	6		6.0		
W. S. W.	6		2.3		5.5
N. E. ½ E.	32	20.3		24.7	
		20.3	12.9	35.8	5.5
		12.9		5.5	
		Diff. Lat. 7.4		Dep. 30.3	

Taking the middle points (viz. S. E. and S. S. W.) between the points to which the ship comes to and falls off, as taught in the rules of lying to, and then allowing, as before, for the variation and lee-way, the traverse table will stand as adjoined.

With the difference of latitude and departure, the course is found to be N. 76° 17′ E., and the distance 31 miles.

Yesterday's latitude	37° 48′ N.
Difference of latitude	7 N.
Latitude in	37 55 N
Sum of latitudes	75 43
Middle latitude	37 51

With the middle latitude 37° 51′ (or 38°) as a course, and the departure 30.3 used as difference of latitude, we find the difference of longitude to be 0° 38′ E.

Yesterday's longitude	58 12 W
Longitude in	57 34 W.

To find the bearing and distance of Funchal.

Latitude in	37° 55′ N.	Longitude in	57° 34′ W
Funchal's latitude ...	32 38 N.	Funchal's longitude	16 54 W
Difference of latitude	5 17 = 317 miles.	Difference of longitude	40 40
			60
Sum of latitudes	70 33		
Middle latitude	35 16	In miles	2440

With the middle latitude 35° 16′, and the difference of longitude 2440, the departure is found to be 1992; with that, and the difference of latitude 317, the bearing of Funchal is found to be S. 80° 57½′ E., and the distance 2017 miles.

Digitized by Google

H.	K.	F.	*Courses.*	*Winds*	*Lee-way.*	Remarks *on board, Thursday, March* 31, 1864.
1	5		E. S. E.	South.	1	Pleasant gales and fair weather.
2	5					
3	5					
4	5					Observed the distance of the planet Venus
5	5	6				from the moon, and found the longitude at
6	5	6				noon to be 54° 31′ by the first method,
7	5	4				page 231.
8	5	4				
9	5	5				Observed the magnetic azimuth of the sun,
10	5	5	E. by S. ½ S.	S. ½ E.	½	and found, by the rules on pages 160–161,
11	6					the variation to be 1 point westerly.
12	6					
1	7					
2	7					
3	7					
4	7					
5	7					
6	7					
7	7					Thermometer at noon................56°
8	7					do. at midnight...........54°
9	7					Barometer at noon.................29.31
10	7					do. at midnight.............29.25
11	8					
12	8					Variation, 1 point westerly, per azimuth.

Course.	*Dist.*	*Diff. Lat.*	*Dep.*	*Lat. by D. R.*	*Lat. by Obs.*	*Diff. Long.*	*Longitude in, by* D. R.	☽ ♀	*Chron.*
East.	151	0	E. 151	N. 37° 55′		E. 3° 11′	W. 54° 23′	54° 31′	54° 25′

The variation and lee-way being allowed on both courses, it appears that the ship has made a due east course; the distance sailed, 151 miles, is the departure; and the difference of longitude is found by Case II. of Parallel Sailing. The latitude in is the same as yesterday's latitude, 37° 55′ N. Taking this as a course, and the departure, 151, as difference of latitude, the distance which corresponds is the difference of longitude, 191 miles .... = 3° 11′ E.

Yesterday's longitude.. 57 34 W

Longitude in .... 54 23 W

To find the bearing and distance of Funchal.

Latitude in.........	37° 55′ N.	Longitude in.............	54° 23′ W.
Funchal's latitude..	32 38 N.	Funchal's longitude.......	16 54 W
Difference of latitude	5 17 = 317 miles.	Difference of longitude....	37 29 W
			60
Sum of latitudes....	70 33		
Middle latitude	35 16	In miles............	2249

Hence, by Case I. of Middle Latitude Sailing, the departure is found to be 1836 miles, the bearing of Funchal S. 80° 12′ E., and the distance 1863 miles.

Digitized by Google

H.	K.	F.	Courses.	Winds.	Lee-way.
1	8		E. S. E.	S. S. W.	
2	8				
3	8				
4	8				
5	8	4			
6	8	4			
7	8	6			
8	8	6			
9	8	5			
10	8	5			
11	8	5			
12	8	5			
1	9		E. by S. ½ S.	S. by W.	
2	9				
3	9				
4	9			South.	
5	8	6			
6	8	6			
7	8	4			
8	8	4			
9	8	5	East.	S. by E.	½
10	8	5			
11	9				
12	9				

REMARKS *on board, Friday, April* 1, 1864

Fresh gales and pleasant weather.
Observed meridian altitude ☉'s lower limb.................57° 06′
Correct for semidiameter, dip, &c.. 12

☉'s correct altitude.............57 18
Subtract from.................90 00

☉'s zenith distance.............32 42 N.
☉'s declination................ 4 48 N.

Latitude to be observed.........37 30 N.

At the sun's setting, observed the bearing of its centre, and from the rules on pages 159 and 161 the true *amplitude* was calculated and the variation found to be 1 point westerly.

Thermometer at noon...............55°
do. at midnight...........51°
Barometer at noon............... ..30.10
do. at midnight.............30.00

Course.	Dist.	Diff. Lat.	Dep.	Lat. by D. R.	Lat. by Obs.	Diff. Long.	Longitude in, by D. R.	Longitude in, by Lun. Obs.	Longitude in, by Chron.
S. 85° 24′ E.	202	S. 16	E. 201	N. 37° 39′	N. 37° 30′	E. 4° 15′	W. 50° 8′		W. 50° 10′

TRAVERSE TABLE.

Courses.	Dist.	N.	S.	E.	W.
E. by S.	100		19.5	98.1	
E. ½ S.	70		6.9	69.7	
E.N.E. ½ E.	35	10.2		33.5	
		10.2	26.4	201.3 Dep.	
			10.2		
		Diff. Lat.	16.2		

The courses being corrected for lee-way and variation, the traverse table will be as here given.

Hence the course is S. 85° 24′ E., distance 202 miles.

Yesterday's latitude .... 37° 55′ N.
Difference of latitude.. ...... 16 S.
Latitude in, by account. ..... 37 39 N.

With the middle latitude 37° 42′, and the departure 201.3, the difference of longitude is 255..............= 4° 15′ E.
Yesterday's longitude......... 54 23 W.
Longitude in by account...... 50 8 W

The latitude by observation differs 9 miles from the latitude by dead-reckoning

H.	K.	F.	*Courses.*	*Winds.*	*Lee-way.*	REMARKS *on board, Saturday, April* 2, 1864.
1	6	5	E. S. E.	South.	½	Fresh gales, with rain.
2	6	5				
3	7	5				
4	7	5				
5	7					
6	7					
7	8		E. S. E.	S. W.	0	
8	8					
9	8	5				Saw a ship to the southward.
10	8	5				This day, took a lunar observation, by
11	8	5				measuring the distance of the moon
12	8	5				from the star Pollux; the longitude at
1	9					noon, deduced from this observation,
2	9					was 45° 50′ W., by the rule on page 231.
3	9					
4	9					
5	9					
6	9					
7	9					Thermo. at noon..................58°
8	9					do. at midnight...............54°
9	9	5				Barom. at noon...................29.76
10	9	5				do. at midnight...............29.72
11	9	5				
12	9	5				Variation, 1 point westerly.

Course.	*Dist.*	*Diff. Lat.*	*Dep.*	*Lat. by D. R.*	*Lat. by Obs.*	*Diff. Long.*	*Longitude in, by* D. R.	☽ *	*Chron.*
S.79° 56′E.	202	S. 35	E. 199	N. 36° 55′		E. 4° 9′	W. 45° 59′	W. 45° 50′	W. 46° 01′

TRAVERSE TABLE.

Courses.	*Dist.*	N.	S.	E.	W.
E. ½ S.	42		4.1	41.8	
E. by S.	160		31.2	156.9	
		Diff. Lat.	35.3	198.7 Dep.	

The lee-way and variation being allowed on the courses, the traverse table will be as here given; hence, the course was S. 79° 56′ E., and the distance 202 miles.

Yesterday's latitude...........	37° 30′	N.
Difference of latitude.........	35	S.
Latitude in....................	36 55	N.
Sum of latitudes...............	74 25	
Middle latitude................	37 12	

With the middle latitude 37° 12′, and the departure 198.7, the difference of long is found to be 249 miles = 4° 9′ E.

Yesterday's longitude.......	50 8	W
Longitude in................	45 59	W.

To find the bearing and distance of Funchal.

Latitude in...........	36° 55′ N.	Longitude in...........	45° 59′ W
Funchal's latitude....	32 38 N.	Funchal's longitude....	16 54 W
Difference of latitude.	4 17 = 257 miles.	Difference of longitude	29 5
			60
Sum of latitudes......	69 33		
Middle latitude.......	34 46	In miles..............	1745

Hence, by Case I. of Middle Latitude Sailing, the bearing of Funchal is found to be S. 79° 50′ E., and its distance 1456 miles.

Digitized by Google

H.	K.	F.	Courses.	Winds.	Lee-way.
1	9	6	E. S. E.	West.	
2	9	6			
3	9	4			
4	9	4			
5	9				
6	9				
7	9				
8	9				
9	9	5			
10	9	5			
11	9	5			
12	9	5			
1	9				
2	9			N. W	
3	9				
4	9				
5	9				
6	9				
7	9				
8	9				
9	9				
10	9			North.	
11	9				
12	9				

REMARKS *on board, Sunday, April* 3, 1864.

Fresh gales and rainy weather; latter part clear.

A great swell from the N. E., for which I allow 9 miles.

Observed altitude ☉'s lower limb at noon	59° 05′
Correct for semidiameter, &c.. add	0 12
☉'s correct altitude.............	59 17
Subtract from	90 00
☉'s zenith distance.............	30 43 N.
☉'s declination	5 34 N.
Latitude observed..............	36 17 N.

Took a lunar observation, by observing the distance of the moon from the star Spica; the resulting longitude at noon was 41° 41′ W.

Observed the magnetic azimuth of the sun, as on March 31, and found the variation to be 1¼ point westerly.

Course.	Dist.	Diff. Lat.	Dep.	Lat. by D. R.	Lat. by Obs.	Diff. Long.	Longitude in, by D. R.	☽ ✱	Chron.
S. 79° 22′ E.	217	S. 40	E. 213	N. 36° 15′	N. 36° 17′	E. 4° 25′	W. 41° 34′	W. 41° 41′	W. 41° 36′

TRAVERSE TABLE.

Courses.	Dist.	N.	S.	E.	W.
E. ¾ S.	220		32.3	217.6	
S. S. W. ¾ W.	9		7.7		4.6
		Diff. Lat.	40.0	217.6	4.6
				4.6	
				213.0 Dep.	

In this day's work, the swell is considered as a current, setting the ship 9 miles per day; and since the swell comes from the N. E., it must set the ship S. W., and allowing the variation S. S. W. ¾ W. 9 miles, these are placed as a course and distance in the traverse table.

With the difference of latitude and departure, the course is found to be S. 79° 22′ E., and the distance 217 miles.

With the middle latitude 36° 36′, and the departure 213 miles, the difference of long. is found, 265 miles = 4° 25′ E.

Yesterday's longitude	45 59 W.
Longitude in................	41 34 W.

Yesterday's latitude	36° 55′ N.
Difference of latitude	40 S.
Latitude in	36 15 N.

To find the bearing and distance of Funchal.

Latitude in.........	36° 17′ N.	Longitude in.............	41° 34′ W.
Funchal's latitude...	32 38 N.	Funchal's longitude.......	16 54 W.
Difference of latitude	3 39 = 219 miles.	Difference of longitude....	24 40 W
			60
Sum of latitudes	68 55		
Middle latitude	34 27	In miles	1480

Hence, by Case I. Middle Latitude Sailing, the bearing of Funchal is found to be S. 79° 50′ E., and its distance 1240 miles.

To find the bearing and distance of Funchal by Mercator's Chart.

Having pricked off the place of the ship at noon, lay a ruler from that point to Funchal; take the nearest distance between the centre of the compass and the ruler; then slide one foot of the compasses along the edge of the ruler, keeping the other foot at the greatest distance from it, and it will be found to run nearly upon the E. by S. line, which is therefore the bearing of Funchal: then take in your compasses the extent from the place of the ship to Funchal, and apply it to the graduated meridian, setting one foot as much above one place as the other is below the other place, and the extent will be found to measure 20½ degrees, or 1230 miles, which was the distance of the ship from Funchal, nearly

Digitized by Google

H.	K.	F.	Courses.	Winds.	Lee-way.	Remarks on board, Monday, April 4, 1864.
1	7	4	E. S. E.	N. E.	1	First part, fresh gales; latter part, more
2	7	4				moderate; a heavy sea running.
3	6	6				Meridian altitude ☉'s lower limb 61° 10′
4	6	6				Correction for semidiameter, &c.. 12
5	6					
6	6					
7	5	4	S. E.	E. N. E.	1	☉'s correct altitude............61 22
8	5	4				Subtract from........ ......90 00
9	4	6				
10	4	6				☉'s zenith distance............28 38 N.
11	4		S. S. E.	East.	1	☉'s declination .... 5 57 N.
12	4					
1	4		S. by E.	E. by S.	1¼	Latitude observed..............34 35 N.
2	4					
3	4					Took a lunar observation, by observing the
4	4					distance of the moon from the planet
5	4	5	S. by E.		1½	Mars, and the longitude at noon, by rule
6	4	5				on page 231, was found to be 40° 17′ W.
7	4					Thermometer at noon...............60°
8	4					do. at midnight.... ......56°
9	4					Barometer at noon 29.61
10	4					do. at midnight............ 29.53
11	4					Variation, 1¼ point westerly.
12	4					

Course.	Dist.	Diff. Lat.	Dep.	Lat. by D. R.	Lat. by Obs.	Diff. Long.	Longitude in, by D. R.	☽ ♂	Chron.
S. 37° 45′ E.	104	S. 82	E. 64	N. 34° 55′	N. 34° 35′	E. 1° 18′	W. 40° 16′	W. 40° 17′	W. 40° 13′

TRAVERSE TABLE.

Courses.	Dist.	N.	S.	E.	W.
E. S. E. ¼ E.	40		13.5	37.7	
S. E. ¼ E.	20		13.4	14.8	
S. S. E. ¼ E.	8		7.2	3.4	
S. by E.	16		15.7	3.1	
S. ¼ E.	33		32.6	4.8	
		Diff. Lat.	82.4	63.8	Dep.

The courses, being corrected for lee-way and variation, will stand as in the adjoined traverse table.

Then, with the difference of latitude, 82.4, and the departure, 63.8, we find the course S. 37° 45′ E. and the distance 104 miles.

Yesterday's latitude	36° 17′ N.
Difference of latitude	1 22 S.
Latitude by account	34 55 N.

Yesterday's latitude	36° 17′ N.
Latitude in by observation	34 35 N.
Sum of latitudes	70 52
Middle latitude	35 26

With the departure, 63.8 miles, and the middle latitude, 35° 26′, we find the diff. of longitude to be 78 miles = 1° 18′ E.

Yesterday's longitude	41 34 W.
Longitude in	40 16 W.

To find the bearing and distance of Funchal.

Latitude in	34° 35′ N.
Funchal's latitude	32 38 N.
Difference of latitude	1 57 = 117 miles.
Middle latitude	33 36

Longitude in	40° 16′ W
Funchal's longitude	16 54 W
Difference of longitude	23 22
	60
In miles	1402

Hence, by Case I. Middle Latitude Sailing, the bearing of Funchal is found to be S 84° 17′ E., and its distance 1174 miles.

Digitized by Google

H.	K.	F.	Courses.	Winds.	Lee-way.	REMARKS on board, Tuesday, April 5, 1864.
1	3		S. E.	E. N. E.	1	First part of these 24 hours, small breezes, and calm; latter part, fresh gales.
2	3					At 4 P. M., got out the boat, and tried the current; found it running E. 1 mile per hour, and suppose the ship has been in this current these 24 hours.
3	2					
4	2					
5						
6			Calm.			
7						
8						
9						Meridian altitude ☉'s lower limb 61° 46′
10						Correction for semidiameter, &c. 12
11						☉'s correct altitude 61 58
12						Subtract from 90 00
1	3	4	E. S. E.	N. N. E.		☉'s zenith distance .... 28 02 N.
2	3	4				☉'s declination .... 6 19 N.
3	4	6				Observed latitude .... 34 21 N.
4	4	6				
5	5	5				
6	5	5				
7	6	5				
8	6	5				Took a lunar observation, by observing the distance of the moon from the planet Saturn; the resulting longitude at noon was 38° 13′ W.
9	7					
10	7					
11	8					
12	8					Variation, 1¼ point westerly.

Course	Dist.	Diff. Lat.	Dep.	Lat. by D. R.	Lat. by Obs.	Diff. Long.	Longitude in, by D. R.	☽ ♄	Chron.
S. 83° 36′ E.	101	S. 11	E. 100	N. 34° 24′	N. 34° 21′	E. 2° 1′	W. 38° 15′	W. 38° 13′	W. 38° 17′*

TRAVERSE TABLE.

Courses.	Dist.	N.	S.	E.	W.
S. E. ¼ E.	10		6.7	7.4	
E. ¾ S.	70		10.3	69.2	
E.N.E. ¾ E.	24	5.8		23.3	
		5.8	17.0	99.9 Dep.	
			5.8		
	Diff. Lat.		11.2		

In addition to the courses sailed, we must also allow 24 miles for the set of the current in the direction of E., per compass, or E. N. E. ¾ E., true course.

With the difference of latitude 11.2, and the departure 99.9, the course is found to be S. 83° 36′ E., and the distance nearly 101 miles.

Yesterday's latitude	34° 35′ N.
Difference of latitude	0 11 S.
Latitude in, by account	34 24 N.

With the middle latitude 34° 28′, and the departure 99.9, we find the difference of longitude to be 121 miles .. = 2° 1′ E.

Yesterday's longitude	40 16 W.
Longitude in	38 15 W.

To find the bearing and distance of Funchal.

Latitude in	34° 21′ N.
Funchal's latitude	32 38 N.
Difference of latitude	1 43 = 103 miles.
Sum of latitudes	66 59
Middle latitude	33 30 nearly.

Longitude in	38° 15′ W
Funchal's longitude	16 54 W
Difference of longitude ..	21 21
	60
In miles	1281

Hence, by Case I. of Middle Latitude Sailing, the bearing of Funchal is found to be S. 84° 30′ E., and its distance 1073 miles.

Digitized by Google

H.	K.	F.	Courses.	Winds.	Lee-way.	REMARKS on board, Wednesday, April 6, 1864.
1	9		E. S. E.	North.		Fine fresh gales, and clear weather.
2	9					
3	9					Meridian altitude ☉'s lower limb 62° 42′
4	9					Correction for dip, &c.......... 12
5	9					
6	9					☉'s correct altitude............62 54
7	9					Subtract from.................90 00
8	9					☉'s zenith distance.............27 06 N.
9	9					☉'s declination................ 6 42 N.
10	9					
11	9					Observed latitude...............33 48 N.
12	9					
1	9					Observed the bearing of the sun's centre at
2	9					setting; the variation therefrom was found
3	9					to be 1¼ point westerly, by the rules on
4	9					pages 159–161.
5	9					Took a lunar observation, by observing the
6	9					distance of the moon from the star Regu-
7	9					lus: the longitude at noon, deduced there-
8	9					from, was 33° 55′ W.
9	9					Thermometer at noon...............61°
10	9					do. at midnight...........58°
11	9					Barometer at noon................29.99
12	9					do. at midnight.............29.91

Course.	Dist.	Diff. Lat.	Dep.	Lat. by D. R.	Lat. by Obs.	Diff. Long.	Longitude in, by D. R.	Longitude in, by ☾ ✱	Longitude in, by Chron.
E. ¾ S.	216	S. 32	E. 214	N. 33° 49′	N. 33° 48′	E. 4° 18′	W. 33° 57′	W. 33° 55′	W. 33° 59′

The course corrected for variation is E. ¾ S., distance 216 miles; hence the difference of latitude is 31.7, and the departure 213.7 miles.

Yesterday's latitude.......... 34° 21′ N.	With the middle latitude 34° 05′, and the departure 213.7 miles, we find the difference of longitude to be 258 miles...................= 4° 18′ E.
Difference of latitude........ 32 S.	Yesterday's longitude....... 38 15 W
Latitude in................. 33 49 N.	Longitude in............... 33 57 W
Sum of latitudes, by obser.... 68 09	
Middle latitude 34 05	

To find the bearing and distance of Funchal.

Latitude in.......... 33° 48′ N.	Longitude in.. .... 33° 57′ W
Funchal's latitude.... 32 38 N.	Funchal's longitude.... 16 54 W
Difference of latitude 1 10 = 70 miles.	Difference of longitude 17 3 W
	60
Sum of latitudes...... 66 26	
Middle latitude....... 33 13	In miles............. 1023

Hence the bearing of Funchal is found to be S. 85° 19′ E., and its distance 859 miles.

H.	K.	F.	*Courses*	*Winds.*	*Lee-way.*	Remarks *on board, Thursday, April* 7, 1864.
1	10		E. S. E.	N. N. W.		Fresh gales and pleasant weather, with a large sea.
2	10					
3	10					
4	10					
5	10					*Observed* the meridian altitude of the moon, and the latitude at noon was found to be, by the rules on pages 170 and 171, 33° 15′ N.
6	10					
7	8	4	S.E.byE.½E.	North.		
8	8	4				
9	8	6				
10	8	6				*Observed* the meridian altitude of Regulus; the resulting latitude at noon, by the rule on page 166, was 33° 11′ N.
11	8	5				
12	8	5				
1	8					
2	8					Observed the magnetic azimuth of the sun, and found the variation, per rules on pages 160 and 161, to be 1½ point westerly.
3	8	5				
4	8	5				
5	8	4				
6	8	4				
7	8	6				Thermo. at noon ....63°
8	8	6				do. at midnight..............61°
9	8					Barom. at noon..................30.22
10	8					do. at midnight.............30.18
11	8					
12	8					Variation, per azimuth, 1½ point westerly.

Course.	*Dist.*	*Diff. Lat.*	*Dep.*	*Lat. by D. R.*	*Lat. by Obs.*	*Diff. Long.*	*Longitude in, by* *D. R.*		*Chron.*
S. 80° 20′ E.	210	S. 35	E. 207	N. 33° 13′		E. 4° 8′	W. 29° 49′		W. 29° 48′

TRAVERSE TABLE.

Courses.	*Dist.*	N.	S.	E.	W.
E. ½ S.	60		5.9	59.7	
E. by S.	150		29.3	147.1	
			Diff. Lat. 35.2	206.8 Dep.	

By the adjoined traverse table, the difference of latitude is 35.2, and the departure 206.8; hence, the course is S. 80° 20′ E., and the distance 209.8, or 210 miles.

Yesterday's latitude	33° 48′ N.
Difference of latitude	35 S.
Latitude in, by account	33 13 N.
Sum of latitudes	67 1
Middle latitude	33 30

With the middle latitude 33° 30′, and the departure 206.8, we find the difference of longitude 248 miles, or.. 4° 8′ E.
Yesterday's longitude .... 33 57 W.
Longitude in............... 29 49 W.

To find the bearing and distance of Funchal.

Latitude in.............	33° 13′ N.
Funchal's latitude.......	32 38 N.
Difference of latitude....	35
Sum of latitudes	65 51
Middle latitude	32 55

Longitude in.............	29° 49 W.
Funchal's longitude.......	16 54 W
Difference of longitude....	12 55
	60
In miles	775

Hence the bearing of Funchal is found to be S. 86° 55′ E., and its distance 652 miles.

Digitized by Google

H.	K.	F.	*Courses*	*Winds.*	*Lee-way.*	REMARKS *on board, Friday, April* 8, 1864.
1	8		E.by S.½ S.	N. N. E.		First part, fresh gales, and clear; latter
2	8					part, rainy weather.
3	8	5				
4	8	5				
5	8	5				
6	8	5				At 6 A. M., the wind hauled suddenly to the
7	8		S. E.	E. N. E.	½	S.S.E.
8	8					Observed the meridian altitude of the planet
9	8					Saturn, and, from the rule on page 174,
10	8					the latitude at noon was 32° 52′ N.
11	8					
12	8					Took a lunar observation, by observing the
1	8					distance of the moon from the planet
2	8					Mars; the longitude at noon, by the method
3	8					on page 231, was found to be 26° 17′ W.
4	8					
5	7	5	East.	S. S. E.	¾	Thermometer at noon...............63°
6	7	5				do. at midnight...........59°
7	7	5				Barometer at noon.................29·95
8	7	5				do. at midnight..............29·91
9	7	5				
10	7	5				
11	7	5				
12	7	5				Variation, 1½ point westerly.

Course.	*Dist.*	*Diff. Lat.*	*Dep.*	*Lat. by D. R.*	*Lat. by Obs.*	*Diff. Long.*	*Longitude in, by* D. R.	☽ ☌	*Chron.*
S.83° 45′ E.	172	S. 19	E. 171	N. 32° 54′		E. 3° 24′	W. 26° 25′	W. 26° 17′	W. 26° 26′

TRAVERSE TABLE.

Courses.	*Dist.*	N.	S.	E.	W.
East.	50			50.0	
S. E. by E.	80		44.4	66.5	
N.E.by E.¾E.	60	25.7		54.2	
		25.7	44.4	170.7 Dep.	
			25.7		
		Diff. Lat.	18.7		

The lee-way and variation being allowed on the courses, they will stand as in the adjoined traverse table; then, with the difference of latitude 18.7, and the departure 170.7, the course is found to be S. 83° 45′ E., and the distance 172 miles.

Yesterday's latitude	33° 13′	N.
Difference of latitude.........	19	S.
Latitude in..................	32 54	N.
Sum of the latitudes..........	66 7	
Middle latitude	33 3	

With the middle latitude 33° 3′, and the departure 170.7, we find the diff. of long. to be nearly 204 miles ..= 3° 24′ E.

Yesterday's longitude	29 49 W.
Longitude in................	26 25 W.

To find the bearing and distance of Funchal.

Latitude in...............	32° 54′ N.
Funchal's latitude.........	32 38 N.
Difference of latitude......	16
Sum of latitudes	65 32
Middle latitude	32 46

Longitude in......... ...	26° 25′ W.
Funchal's longitude... ...	16 54 W.
Difference of longitude ...	9 31
	60
In miles............. ...	571

Hence the bearing of Funchal is found to be S. 88° 5′ E., and its distance 480 miles.

Digitized by Google

H.	K.	F.	Courses.	Winds.	Lee-way.
1	7	5	E. by S. ½ S.	South.	
2	7	5			
3	8				
4	8				
5	8	5			
6	8	5			
7	9				
8	9				
9	9				
10	9				
11	9				
12	9				
1	9				
2	9				
3	9		E. by S.		
4	9				
5	9				
6	9				
7	9				
8	9				
9	9				
10	9				
11	9				
12	9				

REMARKS *on board, Saturday, April* 9, 1864.

Fine breezes, with variable weather.

Meridian altitude ☉'s lower limb	64° 40′	
Correction for dip, &c.	12	
☉'s correct altitude	64 52	
Subtract from	90 00	
☉'s zenith distance	25 8	N.
☉'s declination	7 48	N.
Observed latitude	32 56	N.

Observed the meridian altitude of the planet Mars; and the latitude at noon, by the rule on page 174, was found to be 32° 54′ North.

Took a lunar observation, by observing the distance of the moon from Spica: the longitude at noon, deduced therefrom, was 22° 09′ W.

Thermometer at noon.................64°
do. at midnight...........61°
Barometer at noon..................29.85
do. at midnight..............29.80

Variation, 1½ point westerly.

Course	Dist.	Diff. Lat.	Dep.	Lat. by D. R.	Lat. by Obs.	Diff. Long.	Longitude in, by D. R.	☽ ✱	Chron.
N. 89° 12′ E.	210	N. 3	E. 209	N. 32° 57′	N. 32° 56	E. 4° 10′	W. 22° 15′	W. 22° 09′	W. 22° 17′

TRAVERSE TABLE.

Courses.	Dist.	N.	S.	E.	W.
E. ½ S.	120		5.9	119.9	
E. ½ N.	90	8.8		89.6	
		8.8	5.9	209.5 Dep.	
		5.9			
Diff. Lat.		2.9			

The variation being allowed on the courses, they will stand as in the adjoined table; then, with the difference of latitude 2.9, and the departure 209.5, the course is found to be N. 89° 12′ E., and the distance 210 miles, nearly.

Yesterday's latitude	32° 54′	N.
Difference of latitude	3	N.
Latitude by account	32 57	N.

With the middle latitude 32° 55′, and the departure 209.5, the difference of longitude is found 250 miles... = 4° 10′ E.

Yesterday's longitude	26 25 W.
Longitude in	22 15 W.

To find the bearing and distance of Funchal.

Latitude in	32° 56′ N.
Funchal's latitude	32 38 N.
Difference of latitude	18
Sum of latitudes	65 34
Middle latitude	32 47

Longitude in	22° 15′ W
Funchal's longitude	16 54 W.
Difference of longitude	5 21
	60
In miles	321

Hence the bearing of Funchal is found to be S. 86° 11′ E., and its distance 27? miles.

Digitized by Google

H.	K.	F.	*Courses.*	*Winds.*	*Lee-way.*	REMARKS *on board, Sunday, April* 10, 1864.
1	9	5	S. E. by E.	S. S. W.		All this day, fine breezes, with very clear weather.
2	9	5				
3	9	5				
4	9	5				
5	9	5				
6	9	5				
7	9					
8	9					
9	9					
10	9					
11	9					At 10 A. M., made the land; the southern part of Madeira bearing per compass E. by S. ¾ S., distant 19 leagues.
12	9					
1	9		E.byS.¾ S.			
2	9					
3	9					Observed the distance of the moon from the star Fomalhaut; the longitude at noon was 17° 15′ W.
4	9					
5	9					
6	9					
7	9					Thermometer at noon...............65°
8	9					do. at midnight... ....63°
9	9					Barometer at noon.................29.94
10	9					do. at midnight..............29.90
11						
12						Variation, 1¾ point westerly.

Course.	*Dist.*	*Diff. Lat.*	*Dep.*	*Lat. by D. R.*	*Lat. by Obs.*	*Diff. Long.*	*Longitude in, by* D. R.	☽ ✱	*Chron.*
S.83°57′E.	256	S. 27	E. 255	N. 32° 29′		E. 5° 3′	W. 17° 12′	17° 15′	

TRAVERSE TABLE.

Courses.	*Dist.*	N.	S.	E.	W.
E. S. E. ¾ E.	111		27.0	107.7	
East.	90			90.0	
East.	57			57.0	
		Diff. Lat.	27.0	254.7 Dep.	

In the traverse table are placed the bearing and distance of the land at 10 A. M., (after allowing the variation.) Hence the whole difference of latitude is 27 miles, the departure 254.7, the course S. 83° 57′ E., and the distance 256 miles

Yesterday's latitude..........	32° 56′ N.
Difference of latitude........	27 S.
Latitude by account.........	32 29 N.
Sum of latitudes............	65 25
Middle latitude	32 42

With the middle latitude 32° 42′, and the departure 254.7, the diff. of longitude is found to be 303 miles = 5° 3′ E.

Yesterday's longitude.......	22 15 W.
Longitude of S. part of Madeira	17 12 W

Therefore the latitude of the southern point of Madeira, by account, is 32° 29′ N., and its longitude 17° 12′ W. These values differ but little from those in the Table of Latitudes and Longitudes; we may, therefore, conclude that the Journal is nearly correct, and the latitude and longitude of that part of Madeira well laid down.

Monday, April 11, 1836.—Pleasant gales and fair weather. At 4 P. M., came to off Funchal. At 8 P. M., went on shore.

Digitized by Google

AN ABSTRACT OF THE FOREGOING JOURNAL.

Dates.	Courses.	Dist.	Lat. by D. R.	Lat. by Obs.	Longitude in, by D. R.	Longitude in, by Lun. Obs.	Longitude in, by Chron.	Bearings and Distances of Funchal, at noon.
FRIDAY,.....March 25, 1864.	N. 85° 44′ E.	95	42° 10′ N.		67° 57′ W.		67° 58′ W.	S. 76° 44′ E.; distant 2493 miles.
SATURDAY, ..March 26, "	S. 80 15 E.	162	41 43	41° 43′ N.	64 22		64 20	S. 76 27 E.; " 2326 "
SUNDAY, ...March 27, "	S. 75 56 E.	192	40 56	40 46	60 14	60° 16′ W.	60 13	S. 76 48 E.; " 2137 "
MONDAY,....March 28, "	S. 42 29 E.	138	39 4	39 4	58 12		58 14	S. 79 7 E.; " 2045 "
TUESDAY, ...March 29, "	South.	86	37 38	37 48	58 12	58 17	58 13	S. 81 17 E.; " 2046 "
WEDNESDAY, March 30, "	N. 76 17 E.	31	37 55		57 34		57° 36 W.	S. 80 57½ E.; " 2017 "
THURSDAY, ..March 31, "	East.	151	37 55		54 23	54° 31′ W.	54 25	S. 80 12 E.; " 1863 "
FRIDAY,.....April 1, "	S. 85 24 E.	202	37 39	37 30	50 8		50 10	S. 79 51 E.; " '658 "
SATURDAY, ..April 2, "	S. 79 56 E.	202	36 55		45 59	45 50	46 01	S. 79 50 E.; " .456 "
SUNDAY, ...April 3, "	S. 79 22 E.	217	36 15	36 17	41 34	41 41	41 36	S. 79 50 E.; " 1240 "
MONDAY,....April 4, "	S. 37 45 E.	104	34 55	34 35	40 16	40 17	40 13	S. 84 17 E.; " 1174 "
TUESDAY, ...April 5, "	S. 83 36 E.	101	34 24	34 21	38 15	38 13	38 17	S. 84 30 E.; " 1073 "
WEDNESDAY, April 6, "	S. 81 34 E.	216	33 49	33 48	33 57	33 55	33 59	S. 85 19 E.; " 859 "
THURSDAY, ..April 7, "	S. 80 20 E.	210	33 13		29 49		29 48	S. 86 55 E.; " 652 "
FRIDAY,.....April 8, "	S. 83 45 E.	172	32 54		26 25	26 17	26 26	S. 88 5 E.; " 480 "
SATURDAY, ..April 9, "	N. 89 12 E.	210	32 57	32 56	22 15	22 09	22 17	S. 86 11 E.; " 270 "
SUNDAY, ...April 10, "	S. 83 57 E.	256	32 29		17 12	Made the land, bearing E. by S ¾ S., distant 19 leagues.		
MONDAY, ...April 11, "	Came to anchor, at 4 P. M., in Funchal road.				17° 15			

Digitized by Google

In preparing an abstract of the Log, the following symbols and abbreviations are proposed. Those denoting the force of the wind and the state of the weather, were suggested by Captain Beaufort, R. N., and are used by many navigators.

⊙	Latitude by meridian altitude of the sun.
☽	do. do. do. moon.
✱	do. do. do. star.
⊙⊙ ☽☽ ✱✱	Latitude by double altitudes
L. C.	Longitude by Chronometer.
L. D.	Longitude by Dead reckoning.
l. D.	Latitude by Dead reckoning.
⊙☾ ☽✱	Longitude by Lunar observations.
$\frac{406}{500}$	Temperature in depth.

Figures to denote the force of the wind.

0.	Calm.		
1.	Light air.	Ship has steerage way.	
2.	Light breeze,	or that in which a well-conditioned man-of-war would go in smooth water and clean full,	1 to 2 knots.
3.	Gentle breeze,		3 " 4 "
4.	Moderate breeze,		5 " 6 "
5.	Fresh breeze,	Full and by with	Royals.
6.	Strong breeze,		Top-gallant sails over single reefs
7	Moderate gale,		Double-reefed topsails.
8.	Fresh gale,		Triple-reefed topsails.
9.	Strong gale,		Close-reefed topsails and courses.
10.	Whole gale,	under	Close-reefed main-topsail and reefed foresail.
11.	Storm,	"	Storm stay-sails.
12.	Hurricane,	"	Bare poles

Letters to denote the state of the weather.

- b. Blue sky; whether with clear or hazy atmosphere.
- c. Cloudy; but detached opening clouds.
- d. Drizzling rain.
- f. Foggy—F, thick fog.
- g. Gloomy, dark weather.
- h. Hail.
- l. Lightning.
- m. Misty, hazy atmosphere.
- o. Overcast; the whole sky being covered with an impervious cloud.
- p. Passing temporary showers.
- q. Squally.
- r. Rain; continued rain.
- s. Snow.
- t. Thunder.
- u. Ugly, threatening appearance of the weather.
- v. Visibility of distant objects whether the sky be cloudy or not.
- w. Wet dew.
- . Under any letter, indicates an extraordinary degree.

All tne ordinary phenomena of the weather may be easily recorded by the combination of these letters. Thus:

g. ṿ. Gloomy, dark weather, but distant objects remarkably visible

Digitized by Google

[Continued from page 268.]

EXAMPLE X.

Suppose a vessel in a port in west longitude on the 6th of June, 1836, finds the daily rate of the chronometer to be + 5ˢ, and after steering west, in 18 days arrives on the 24th of June in port, and finds by observation that the daily rate is + 8ˢ. Required the correction of the observed longitude on the 18th of June.

The daily rate at the *first* port is	5ˢ
The daily rate at the *second* port is	8ˢ
Sum	13
Mean daily rate	6ˢ.5

Let the difference of longitude between the two places by the *first* daily rate be	23° 50′ 00″
And by the *mean* daily rate	23 43 15
Difference is the correction of the longitude of the *second port* for 18 days, and is *easterly*	6 45

Log. of the *correction* of the *second port*, 6′ 45″ = 405″	2.60746
Log. of 18 days by Table A. ar. co.	7.76700
Constant Log	10.37446
Log. of 12 days (from 6th to 18th of June) by Table A.	1.89209
Log. of correction, 184″.7 = 3′ 4″ 7	2.26655

This correction, it is evident, gives the place of observation on the 18th more easterly, because the second place of observation is to the eastward of the position given by the daily rate at the port of departure.

Having the *constant logarithm* as above, the corrections for the other days are readily found, by substituting for the log. of 12 days the log. from Table A. of the days elapsed since the rate was first ascertained.

This method, by Rossel, is found in the 3d vol. of Biot. Astronomie Physique. The logarithms are used in the same manner as proposed by Galbraith.

TABLE A.

Days.	Log.	Days.	Log.	Days.	Log.	Days.	Log.	Days.	Log.	Days.	Log.
1	0.00000	21	2.36361	41	2.93500	61	3.27669	81	3.52127	101	3.71189
2	0.47712	22	2.40312	42	2.95569	62	3.29070	82	3.53186	102	3.72041
3	0.77815	23	2.44091	43	2.97589	63	3.30449	83	3.54233	103	3.72884
4	1.00000	24	2.47712	44	2.99564	64	3.31806	84	3.55267	104	3.73719
5	1.17609	25	2.51186	45	3.01494	65	3.33143	85	3.56289	105	3.74547
6	1.32222	26	2.54531	46	3.03383	66	3.34459	86	3.57299	106	3.75366
7	1.44716	27	2.57749	47	3.05231	67	3.35755	87	3.58297	107	3.76178
8	1.55630	28	2.60853	48	3.07041	68	3.37033	88	3.59284	108	3.76982
9	1.65321	29	2.63849	49	3.08814	69	3.38292	89	3.60260	109	3.77779
10	1.74036	30	2.66745	50	3.10551	70	3.39533	90	3.61225	110	3.78569
11	1.81954	31	2.69548	51	3.12254	71	3.40756	91	3.62180	111	3.79351
12	1.89209	32	2.72263	52	3.13925	72	3.41963	92	3.63124	112	3.80127
13	1.95904	33	2.74896	53	3.15564	73	3.43152	93	3.64058	113	3.80895
14	2.02119	34	2.77452	54	3.17173	74	3.44326	94	3 64982	114	3.81657
15	2.07918	35	2.79934	55	3.18752	75	3.45484	95	3.65896	115	3.82413
16	2.13354	36	2.82347	56	3.20303	76	3.46627	96	3.66801	116	3.83161
17	2.18469	37	2.84696	57	3.21827	77	3.47756	97	3.67697	117	3.83904
18	2.23300	38	2.86982	58	3.23325	78	3.48869	98	3.68583	118	3.84640
19	2.27875	39	2.89209	59	3.24797	79	3.49969	99	3.69461	119	3.85370
20	2.32222	40	2.91381	60	3.26245	80	3.51055	100	3.70329	120	3.86094

Digitized by Google

Digitized by Google

TABLE I.

Difference of Latitude and Departure for ¼ Point.

N. ¼ E. N. ¼ W. S. ¼ E. S. ¼ W.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.0	61	60.9	03.0	121	120.9	05.9	181	180.8	08.9	241	240.7	11.8
2	02.0	00.1	62	61.9	03.0	22	121.9	06.0	82	181.8	08.9	42	241.7	11.9
3	03.0	00.1	63	62.9	03.1	23	122.9	06.0	83	182.8	09.0	43	242.7	11.9
4	04.0	00.2	64	63.9	03.1	24	123.9	06.1	84	183.8	09.0	44	243.7	12.0
5	05.0	00.2	65	64.9	03.2	25	124.8	06.1	85	184.8	09.1	45	244.7	12.0
6	06.0	00.3	66	65.9	03.2	26	125.8	06.2	86	185.8	09.1	46	245.7	12.1
7	07.0	00.3	67	66.9	03.3	27	126.8	06.2	87	186.8	09.2	47	246.7	12.1
8	08.0	00.4	68	67.9	03.3	28	127.8	06.3	88	187.8	09.2	48	247.7	12.2
9	09.0	00.4	69	68.9	03.4	29	128.8	06.3	89	188.8	09.3	49	248.7	12.2
10	10.0	00.5	70	69.9	03.4	30	129.8	06.4	90	189.8	09.3	50	249.7	12.3
11	11.0	00.5	71	70.9	03.5	131	130.8	06.4	191	190.8	09.4	251	250.7	12.3
12	12.0	00.6	72	71.9	03.5	32	131.8	06.5	92	191.8	09.4	52	251.7	12.4
13	13.0	00.6	73	72.9	03.6	33	132.8	06.5	93	192.8	09.5	53	252.7	12.4
14	14.0	00.7	74	73.9	03.6	34	133.8	06.6	94	193.8	09.5	54	253.7	12.5
15	15.0	00.7	75	74.9	03.7	35	134.8	06.6	95	194.8	09.6	55	254.7	12.5
16	16.0	00.8	76	75.9	03.7	36	135.8	06.7	96	195.8	09.6	56	255.7	12.6
17	17.0	00.8	77	76.9	03.8	37	136.8	06.7	97	196.8	09.7	57	256.7	12.6
18	18.0	00.9	78	77.9	03.8	38	137.8	06.8	98	197.8	09.7	58	257.7	12.7
19	19.0	00.9	79	78.9	03.9	39	138.8	06.8	99	198.8	09.8	59	258.7	12.7
20	20.0	01.0	80	79.9	03.9	40	139.8	06.9	200	199.8	09.8	60	259.7	12.8
21	21.0	01.0	81	80.9	04.0	141	140.8	06.9	201	200.8	09.9	261	260.7	12.8
22	22.0	01.1	82	81.9	04.0	42	141.8	07.0	02	201.8	09.9	62	261.7	12.9
23	23.0	01.1	83	82.9	04.1	43	142.8	07.0	03	202.8	10.0	63	262.7	12.9
24	24.0	01.2	84	83.9	04.1	44	143.8	07.1	04	203.8	10.0	64	263.7	13.0
25	25.0	01.2	85	84.9	04.2	45	144.8	07.1	05	204.8	10.1	65	264.7	13.0
26	26.0	01.3	86	85.9	04.2	46	145.8	07.2	06	205.8	10.1	66	265.7	13.1
27	27.0	01.3	87	86.9	04.3	47	146.8	07.2	07	206.8	10.2	67	266.7	13.1
28	28.0	01.4	88	87.9	04.3	48	147.8	07.3	08	207.7	10.2	68	267.7	13.2
29	29.0	01.4	89	88.9	04.4	49	148.8	07.3	09	208.7	10.3	69	268.7	13.2
30	30.0	01.5	90	89.9	04.4	50	149.8	07.4	10	209.7	10.3	70	269.7	13.2
31	31.0	01.5	91	90.9	04.5	151	150.8	07.4	211	210.7	10.4	271	270.7	13.3
32	32.0	01.6	92	91.9	04.5	52	151.8	07.5	12	211.7	10.4	72	271.7	13.3
33	33.0	01.6	93	92.9	04.6	53	152.8	07.5	13	212.7	10.5	73	272.7	13.4
34	34.0	01.7	94	93.9	04.6	54	153.8	07.6	14	213.7	10.5	74	273.7	13.4
35	35.0	01.7	95	94.9	04.7	55	154.8	07.6	15	214.7	10.5	75	274.7	13.5
36	36.0	01.8	96	95.9	04.7	56	155.8	07.7	16	215.7	10.6	76	275.7	13.5
37	37.0	01.8	97	96.9	04.8	57	156.8	07.7	17	216.7	10.6	77	276.7	13.6
38	38.0	01.9	98	97.9	04.8	58	157.8	07.8	18	217.7	10.7	78	277.7	13.6
39	39.0	01.9	99	98.9	04.9	59	158.8	07.8	19	218.7	10.7	79	278.7	13.7
40	40.0	02.0	100	99.9	04.9	60	159.8	07.9	20	219.7	10.8	80	279.7	13.7
41	41.0	02.0	101	100.9	05.0	161	160.8	07.9	221	220.7	10.8	281	280.7	13.8
42	41.9	02.1	02	101.9	05.0	62	161.8	07.9	22	221.7	10.9	82	281.7	13.8
43	42.9	02.1	03	102.9	05.1	63	162.8	08.0	23	222.7	10.9	83	282.7	13.9
44	43.9	02.2	04	103.9	05.1	64	163.8	08.0	24	223.7	11.0	84	283.7	13.9
45	44.9	02.2	05	104.9	05.2	65	164.8	08.1	25	224.7	11.0	85	284.7	14.0
46	45.9	02.3	06	105.9	05.2	66	165.8	08.1	26	225.7	11.1	86	285.7	14.0
47	46.9	02.3	07	106.9	05.3	67	166.8	08.2	27	226.7	11.1	87	286.7	14.1
48	47.9	02.4	08	107.9	05.3	68	167.8	08.2	28	227.7	11.2	88	287.7	14.1
49	48.9	02.4	09	108.9	05.3	69	168.8	08.3	29	228.7	11.2	89	288.7	14.2
50	49.9	02.5	10	109.9	05.4	70	169.8	08.3	30	229.7	11.3	90	289.7	14.2
51	50.9	02.5	111	110.9	05.4	171	170.8	08.4	231	230.7	11.3	291	290.6	14.3
52	51.9	02.6	12	111.9	05.5	72	171.8	08.4	32	231.7	11.4	92	291.6	14.3
53	52.9	02.6	13	112.9	05.5	73	172.8	08.5	33	232.7	11.4	93	292.6	14.4
54	53.9	02.6	14	113.9	05.6	74	173.8	08.5	34	233.7	11.5	94	293.6	14.4
55	54.9	02.7	15	114.9	05.6	75	174.8	08.6	35	234.7	11.5	95	294.6	14.5
56	55.9	02.7	16	115.9	05.7	76	175.8	08.6	36	235.7	11.6	96	295.6	14.5
57	56.9	02.8	17	116.9	05.7	77	176.8	08.7	37	236.7	11.6	97	296.6	14.6
58	57.9	02.8	18	117.9	05.8	78	177.8	08.7	38	237.7	11.7	98	297.6	14.6
59	58.9	02.9	19	118.9	05.8	79	178.8	08.8	39	238.7	11.7	99	298.6	14.7
60	59.9	02.9	20	119.9	05.9	80	179.8	08.8	40	239.7	11.8	300	299.6	14.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

E. ¼ N. E. ¼ S. W. ¼ N. W. ¼ S. [For 7¾ Points.

Digitized by Google

TABLE I.

Difference of Latitude and Departure for ½ Point.

N.½ E. N.½ W. S.½ E. S.½ W.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.7	06.0	121	120.4	11.9	181	180.1	17.7	241	239.8	23.6
2	02.0	00.2	62	61.7	06.1	22	121.4	12.0	82	181.1	17.8	42	240.8	23.7
3	03.0	00.3	63	62.7	06.2	23	122.4	12.1	83	182.1	17.9	43	241.8	23.8
4	04.0	00.4	64	63.7	06.3	24	123.4	12.2	84	183.1	18.0	44	242.8	23.9
5	05.0	00.5	65	64.7	06.4	25	124.4	12.3	85	184.1	18.1	45	243.8	24.0
6	06.0	00.6	66	65.7	06.5	26	125.4	12.4	86	185.1	18.2	46	244.8	24.1
7	07.0	00.7	67	66.7	06.6	27	126.4	12.4	87	186.1	18.3	47	245.8	24.2
8	08.0	00.8	68	67.7	06.7	28	127.4	12.5	88	187.1	18.4	48	246.8	24.3
9	09.0	00.9	69	68.7	06.8	29	128.4	12.6	89	188.1	18.5	49	247.8	24.4
10	10.0	01.0	70	69.7	06.9	30	129.4	12.7	90	189.1	18.6	50	248.8	24.5
11	10.9	01.1	71	70.7	07.0	131	130.4	12.8	191	190.1	18.7	251	249.8	24.6
12	11.9	01.2	72	71.7	07.1	32	131.4	12.9	92	191.1	18.8	52	250.8	24.7
13	12.9	01.3	73	72.6	07.2	33	132.4	13.0	93	192.1	18.9	53	251.8	24.8
14	13.9	01.4	74	73.6	07.3	34	133.4	13.1	94	193.1	19.0	54	252.8	24.9
15	14.9	01.5	75	74.6	07.4	35	134.3	13.2	95	194.1	19.1	55	253.8	25.0
16	15.9	01.6	76	75.6	07.4	36	135.3	13.3	96	195.1	19.2	56	254.8	25.1
17	16.9	01.7	77	76.6	07.5	37	136.3	13.4	97	196.1	19.3	57	255.8	25.2
18	17.9	01.8	78	77.6	07.6	38	137.3	13.5	98	197.0	19.4	58	256.8	25.3
19	18.9	01.9	79	78.6	07.7	39	138.3	13.6	99	198.0	19.5	59	257.8	25.4
20	19.9	02.0	80	79.6	07.8	40	139.3	13.7	200	199.0	19.6	60	258.7	25.5
21	20.9	02.1	81	80.6	07.9	141	140.3	13.8	201	200.0	19.7	261	259.7	25.6
22	21.9	02.2	82	81.6	08.0	42	141.3	13.9	02	201.0	19.8	62	260.7	25.7
23	22.9	02.3	83	82.6	08.1	43	142.3	14.0	03	202.0	19.9	63	261.7	25.8
24	23.9	02.4	84	83.6	08.2	44	143.3	14.1	04	203.0	20.0	64	262.7	25.9
25	24.9	02.5	85	84.6	08.3	45	144.3	14.2	05	204.0	20.1	65	263.7	26.0
26	25.9	02.5	86	85.6	08.4	46	145.3	14.3	06	205.0	20.2	66	264.7	26.1
27	26.9	02.6	87	86.6	08.5	47	146.3	14.4	07	206.0	20.3	67	265.7	26.2
28	27.9	02.7	88	87.6	08.6	48	147.3	14.5	08	207.0	20.4	68	266.7	26.3
29	28.9	02.8	89	88.6	08.7	49	148.3	14.6	09	208.0	20.5	69	267.7	26.4
30	29.9	02.9	90	89.6	08.8	50	149.3	14.7	10	209.0	20.6	70	268.7	26.5
31	30.9	03.0	91	90.6	08.9	151	150.3	14.8	211	210.0	20.7	271	269.7	26.6
32	31.8	03.1	92	91.6	09.0	52	151.3	14.9	12	211.0	20.8	72	270.7	26.7
33	32.8	03.2	93	92.6	09.1	53	152.3	15.0	13	212.0	20.9	73	271.7	26.8
34	33.8	03.3	94	93.5	09.2	54	153.3	15.1	14	213.0	21.0	74	272.7	26.9
35	34.8	03.4	95	94.5	09.3	55	154.3	15.2	15	214.0	21.1	75	273.7	27.0
36	35.8	03.5	96	95.5	09.4	56	155.2	15.3	16	215.0	21.2	76	274.7	27.1
37	36.8	03.6	97	96.5	09.5	57	156.2	15.4	17	216.0	21.3	77	275.7	27.2
38	37.8	03.7	98	97.5	09.6	58	157.2	15.5	18	217.0	21.4	78	276.7	27.2
39	38.8	03.8	99	98.5	09.7	59	158.2	15.6	19	217.9	21.5	79	277.7	27.3
40	39.8	03.9	100	99.5	09.8	60	159.2	15.7	20	218.9	21.6	80	278.7	27.4
41	40.8	04.0	101	100.5	09.9	161	160.2	15.8	221	219.9	21.7	281	279.6	27.5
42	41.8	04.1	02	101.5	10.0	62	161.2	15.9	22	220.9	21.8	82	280.6	27.6
43	42.8	04.2	03	102.5	10.1	63	162.2	16.0	23	221.9	21.9	83	281.6	27.7
44	43.8	04.3	04	103.5	10.2	64	163.2	16.1	24	222.9	22.0	84	282.6	27.8
45	44.8	04.4	05	104.5	10.3	65	164.2	16.2	25	223.9	22.1	85	283.6	27.9
46	45.8	04.5	06	105.5	10.4	66	165.2	16.3	26	224.9	22.2	86	284.6	28.0
47	46.8	04.6	07	106.5	10.5	67	166.2	16.4	27	225.9	22.2	87	285.6	28.1
48	47.8	04.7	08	107.5	10.6	68	167.2	16.5	28	226.9	22.3	88	286.6	28.2
49	48.8	04.8	09	108.5	10.7	69	168.2	16.6	29	227.9	22.4	89	287.6	28.3
50	49.8	04.9	10	109.5	10.8	70	169.2	16.7	30	228.9	22.5	90	288.6	28.4
51	50.8	05.0	111	110.5	10.9	171	170.2	16.8	231	229.9	22.6	291	289.6	28.5
52	51.7	05.1	12	111.5	11.0	72	171.2	16.9	32	230.9	22.7	92	290.6	28.6
53	52.7	05.2	13	112.5	11.1	73	172.2	17.0	33	231.9	22.8	93	291.6	28.7
54	53.7	05.3	14	113.5	11.2	74	173.2	17.1	34	232.9	22.9	94	292.6	28.8
55	54.7	05.4	15	114.4	11.3	75	174.2	17.2	35	233.9	23.0	95	293.6	28.9
56	55.7	05.5	16	115.4	11.4	76	175.2	17.3	36	234.9	23.1	96	294.6	29.0
57	56.7	05.6	17	116.4	11.5	77	176.1	17.3	37	235.9	23.2	97	295.6	29.1
58	57.7	05.7	18	117.4	11.6	78	177.1	17.4	38	236.9	23.3	98	296.6	29.2
59	58.7	05.8	19	118.4	11.7	79	178.1	17.5	39	237.8	23.4	99	297.6	29.3
60	59.7	05.9	20	119.4	11.8	80	179.1	17.6	40	238.8	23.5	300	298.6	29.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

E.½ N. E.½ S. W.½ N. W.½ S. [For 7½ Points.

TABLE I.

Difference of Latitude and Departure for ¾ Point.

N.¾ E. N.¾ W. S.¾ E. S.¾ W.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.3	09.0	121	119.7	17.8	181	179.0	26.6	241	238.4	35.4
2	02.0	00.3	62	61.3	09.1	22	120.7	17.9	82	180.0	26.7	42	239.4	35.5
3	03.0	00.4	63	62.3	09.2	23	121.7	18.0	83	181.0	26.9	43	240.4	35.7
4	04.0	00.6	64	63.3	09.4	24	122.7	18.2	84	182.0	27.0	44	241.4	35.8
5	04.9	00.7	65	64.3	09.5	25	123.6	18.3	85	183.0	27.1	45	242.3	35.9
6	05.9	00.9	66	65.3	09.7	26	124.6	18.5	86	184.0	27.3	46	243.3	36.1
7	06.9	01.0	67	66.3	09.8	27	125.6	18.6	87	185.0	27.4	47	244.3	36.2
8	07.9	01.2	68	67.3	10.0	28	126.6	18.8	88	186.0	27.6	48	245.3	36.4
9	08.9	01.3	69	68.3	10.1	29	127.6	18.9	89	187.0	27.7	49	246.3	36.5
10	09.9	01.5	70	69.2	10.3	30	128.6	19.1	90	187.9	27.9	50	247.3	36.7
11	10.9	01.6	71	70.2	10.4	131	129.6	19.2	191	188.9	28.0	251	248.3	36.8
12	11.9	01.8	72	71.2	10.6	32	130.6	19.4	92	189.9	28.2	52	249.3	37.0
13	12.9	01.9	73	72.2	10.7	33	131.6	19.5	93	190.9	28.3	53	250.3	37.1
14	13.8	02.1	74	73.2	10.9	34	132.5	19.7	94	191.9	28.5	54	251.3	37.3
15	14.8	02.2	75	74.2	11.0	35	133.5	19.8	95	192.9	28.6	55	252.2	37.4
16	15.8	02.3	76	75.2	11.2	36	134.5	20.0	96	193.9	28.8	56	253.2	37.6
17	16.8	02.5	77	76.2	11.3	37	135.5	20.1	97	194.9	28.9	57	254.2	37.7
18	17.8	02.6	78	77.2	11.4	38	136.5	20.2	98	195.9	29.1	58	255.2	37.9
19	18.8	02.8	79	78.1	11.6	39	137.5	20.4	99	196.8	29.2	59	256.2	38.0
20	19.8	02.9	80	79.1	11.7	40	138.5	20.5	200	197.8	29.3	60	257.2	38.1
21	20.8	03.1	81	80.1	11.9	141	139.5	20.7	201	198.8	29.5	261	258.2	38.3
22	21.8	03.2	82	81.1	12.0	42	140.5	20.8	02	199.8	29.6	62	259.2	38.4
23	22.8	03.4	83	82.1	12.2	43	141.5	21.0	03	200.8	29.8	63	260.2	38.6
24	23.7	03.5	84	83.1	12.3	44	142.4	21.1	04	201.8	29.9	64	261.1	38.7
25	24.7	03.7	85	84.1	12.5	45	143.4	21.3	05	202.8	30.1	65	262.1	38.9
26	25.7	03.8	86	85.1	12.6	46	144.4	21.4	06	203.8	30.2	66	263.1	39.0
27	26.7	04.0	87	86.1	12.8	47	145.4	21.6	07	204.8	30.4	67	264.1	39.2
28	27.7	04.1	88	87.0	12.9	48	146.4	21.7	08	205.7	30.5	68	265.1	39.3
29	28.7	04.3	89	88.0	13.1	49	147.4	21.9	09	206.7	30.7	69	266.1	39.5
30	29.7	04.4	90	89.0	13.2	50	148.4	22.0	10	207.7	30.8	70	267.1	39.6
31	30.7	04.5	91	90.0	13.4	151	149.4	22.2	211	208.7	31.0	271	268.1	39.8
32	31.7	04.7	92	91.0	13.5	52	150.4	22.3	12	209.7	31.1	72	269.1	39.9
33	32.6	04.8	93	92.0	13.6	53	151.3	22.4	13	210.7	31.3	73	270.0	40.1
34	33.6	05.0	94	93.0	13.8	54	152.3	22.6	14	211.7	31.4	74	271.0	40.2
35	34.6	05.1	95	94.0	13.9	55	153.3	22.7	15	212.7	31.5	75	272.0	40.4
36	35.6	05.3	96	95.0	14.1	56	154.3	22.9	16	213.7	31.7	76	273.0	40.5
37	36.6	05.4	97	96.0	14.2	57	155.3	23.0	17	214.7	31.8	77	274.0	40.6
38	37.6	05.6	98	96.9	14.4	58	156.3	23.2	18	215.6	32.0	78	275.0	40.8
39	38.6	05.7	99	97.9	14.5	59	157.3	23.3	19	216.6	32.1	79	276.0	40.9
40	39.6	05.9	100	98.9	14.7	60	158.3	23.5	20	217.6	32.3	80	277.0	41.1
41	40.6	06.0	101	99.9	14.8	161	159.3	23.6	221	218.6	32.4	281	278.0	41.2
42	41.5	06.2	02	100.9	15.0	62	160.2	23.8	22	219.6	32.6	82	278.9	41.4
43	42.5	06.3	03	101.9	15.1	63	161.2	23.9	23	220.6	32.7	83	279.9	41.5
44	43.5	06.5	04	102.9	15.3	64	162.2	24.1	24	221.6	32.9	84	280.9	41.7
45	44.5	06.6	05	103.9	15.4	65	163.2	24.2	25	222.6	33.0	85	281.9	41.8
46	45.5	06.7	06	104.9	15.6	66	164.2	24.4	26	223.6	33.2	86	282.9	42.0
47	46.5	06.9	07	105.8	15.7	67	165.2	24.5	27	224.5	33.3	87	283.9	42.1
48	47.5	07.0	08	106.8	15.8	68	166.2	24.7	28	225.5	33.5	88	284.9	42.3
49	48.5	07.2	09	107.8	16.0	69	167.2	24.8	29	226.5	33.6	89	285.9	42.4
50	49.5	07.3	10	108.8	16.1	70	168.2	24.9	30	227.5	33.7	90	286.9	42.6
51	50.4	07.5	111	109.8	16.3	171	169.1	25.1	231	228.5	33.9	291	287.9	42.7
52	51.4	07.6	12	110.8	16.4	72	170.1	25.2	32	229.5	34.0	92	288.8	42.8
53	52.4	07.8	13	111.8	16.6	73	171.1	25.4	33	230.5	34.2	93	289.8	43.0
54	53.4	07.9	14	112.8	16.7	74	172.1	25.5	34	231.5	34.3	94	290.8	43.1
55	54.4	08.1	15	113.8	16.9	75	173.1	25.7	35	232.5	34.5	95	291.8	43.3
56	55.4	08.2	16	114.7	17.0	76	174.1	25.8	36	233.4	34.6	96	292.8	43.4
57	56.4	08.4	17	115.7	17.2	77	175.1	26.0	37	234.4	34.8	97	293.8	43.6
58	57.4	08.5	18	116.7	17.3	78	176.1	26.1	38	235.4	34.9	98	294.8	43.7
59	58.4	08.7	19	117.7	17.5	79	177.1	26.3	39	236.4	35.1	99	295.8	43.9
60	59.4	08.8	20	118.7	17.6	80	178.1	26.4	40	237.4	35.2	300	296.8	44.0
Dist	Dep.	Lat.	Dist	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

E.¾ N. E.¾ S. W.¾ N. W.¾ S. [For 7¼ Points

Digitized by Google

TABLE I.

Difference of Latitude and Departure for 1 Point.

N by E. N. by W. S. by E. S. by W.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	59.8	11.9	121	118.7	23.6	181	177.5	35.3	241	236.4	47.0
2	02.0	00.4	62	60.8	12.1	22	119.7	23.8	82	178.5	35.5	42	237.4	47.2
3	02.9	00.6	63	61.8	12.3	23	120.6	24.0	83	179.5	35.7	43	238.3	47.4
4	03.9	00.8	64	62.8	12.5	24	121.6	24.2	84	180.5	35.9	44	239.3	47.6
5	04.9	01.0	65	63.8	12.7	25	122.6	24.4	85	181.4	36.1	45	240.3	47.8
6	05.9	01.2	66	64.7	12.9	26	123.6	24.6	86	182.4	36.3	46	241.3	48.0
7	06.9	01.4	67	65.7	13.1	27	124.6	24.8	87	183.4	36.5	47	242.3	48.2
8	07.8	01.6	68	66.7	13.3	28	125.5	25.0	88	184.4	36.7	48	243.2	48.4
9	08.8	01.8	69	67.7	13.5	29	126.5	25.2	89	185.4	36.9	49	244.2	48.6
10	09.8	02.0	70	68.7	13.7	30	127.5	25.4	90	186.3	37.1	50	245.2	48.8
11	10.8	02.1	71	69.6	13.9	131	128.5	25.6	191	187.3	37.3	251	246.2	49.0
12	11.8	02.3	72	70.6	14.0	32	129.5	25.8	92	188.3	37.5	52	247.2	49.2
13	12.8	02.5	73	71.6	14.2	33	130.4	25.9	93	189.3	37.7	53	248.1	49.4
14	13.7	02.7	74	72.6	14.4	34	131.4	26.1	94	190.3	37.8	54	249.1	49.6
15	14.7	02.9	75	73.6	14.6	35	132.4	26.3	95	191.3	38.0	55	250.1	49.7
16	15.7	03.1	76	74.5	14.8	36	133.4	26.5	96	192.2	38.2	56	251.1	49.9
17	16.7	03.3	77	75.5	15.0	37	134.4	26.7	97	193.2	38.4	57	252.1	50.1
18	17.7	03.5	78	76.5	15.2	38	135.3	26.9	98	194.2	38.6	58	253.0	50.3
19	18.6	03.7	79	77.5	15.4	39	136.3	27.1	99	195.2	38.8	59	254.0	50.5
20	19.6	03.9	80	78.5	15.6	40	137.3	27.3	200	196.2	39.0	60	255.0	50.7
21	20.6	04.1	81	79.4	15.8	141	138.3	27.5	201	197.1	39.2	261	256.0	50.9
22	21.6	04.3	82	80.4	16.0	42	139.3	27.7	02	198.1	39.4	62	257.0	51.1
23	22.6	04.5	83	81.4	16.2	43	140.3	27.9	03	199.1	39.6	63	257.9	51.3
24	23.5	04.7	84	82.4	16.4	44	141.2	28.1	04	200.1	39.8	64	258.9	51.5
25	24.5	04.9	85	83.4	16.6	45	142.2	28.3	05	201.1	40.0	65	259.9	51.7
26	25.5	05.1	86	84.3	16.8	46	143.2	28.5	06	202.0	40.2	66	260.9	51.9
27	26.5	05.3	87	85.3	17.0	47	144.2	28.7	07	203.0	40.4	67	261.9	52.1
28	27.5	05.5	88	86.3	17.2	48	145.2	28.9	08	204.0	40.6	68	262.9	52.3
29	28.4	05.7	89	87.3	17.4	49	146.1	29.1	09	205.0	40.8	69	263.8	52.5
30	29.4	05.9	90	88.3	17.6	50	147.1	29.3	10	206.0	41.0	70	264.8	52.7
31	30.4	06.0	91	89.3	17.8	151	148.1	29.5	211	206.9	41.2	271	265.8	52.9
32	31.4	06.2	92	90.2	17.9	52	149.1	29.7	12	207.9	41.4	72	266.8	53.1
33	32.4	06.4	93	91.2	18.1	53	150.1	29.8	13	208.9	41.6	73	267.8	53.3
34	33.3	06.6	94	92.2	18.3	54	151.0	30.0	14	209.9	41.7	74	268.7	53.5
35	34.3	06.8	95	93.2	18.5	55	152.0	30.2	15	210.9	41.9	75	269.7	53.6
36	35.3	07.0	96	94.2	18.7	56	153.0	30.4	16	211.8	42.1	76	270.7	53.8
37	36.3	07.2	97	95.1	18.9	57	154.0	30.6	17	212.8	42.3	77	271.7	54.0
38	37.3	07.4	98	96.1	19.1	58	155.0	30.8	18	213.8	42.5	78	272.7	54.2
39	38.3	07.6	99	97.1	19.3	59	155.9	31.0	19	214.8	42.7	79	273.6	54.4
40	39.2	07.8	100	98.1	19.5	60	156.9	31.2	20	215.8	42.9	80	274.6	54.6
41	40.2	08.0	101	99.1	19.7	161	157.9	31.4	221	216.8	43.1	281	275.6	54.8
42	41.2	08.2	02	100.0	19.9	62	158.9	31.6	22	217.7	43.3	82	276.6	55.0
43	42.2	08.4	03	101.0	20.1	63	159.9	31.8	23	218.7	43.5	83	277.6	55.2
44	43.2	08.6	04	102.0	20.3	64	160.8	32.0	24	219.7	43.7	84	278.5	55.4
45	44.1	08.8	05	103.0	20.5	65	161.8	32.2	25	220.7	43.9	85	279.5	55.6
46	45.1	09.0	06	104.0	20.7	66	162.8	32.4	26	221.7	44.1	86	280.5	55.8
47	46.1	09.2	07	104.9	20.9	67	163.8	32.6	27	222.6	44.3	87	281.5	56.0
48	47.1	09.4	08	105.9	21.1	68	164.8	32.8	28	223.6	44.5	88	282.5	56.2
49	48.1	09.6	09	106.9	21.3	69	165.8	33.0	29	224.6	44.7	89	283.4	56.4
50	49.0	09.8	10	107.9	21.5	70	166.7	33.2	30	225.6	44.9	90	284.4	56.6
51	50.0	09.9	111	108.9	21.7	171	167.7	33.4	231	226.6	45.1	291	285.4	56.8
52	51.0	10.1	12	109.8	21.9	72	168.7	33.6	32	227.5	45.3	92	286.4	57.0
53	52.0	10.3	13	110.8	22.0	73	169.7	33.8	33	228.5	45.5	93	287.4	57.2
54	53.0	10.5	14	111.8	22.2	74	170.7	33.9	34	229.5	45.7	94	288.4	57.4
55	53.9	10.7	15	112.8	22.4	75	171.6	34.1	35	230.5	45.8	95	289.3	57.6
56	54.9	10.9	16	113.8	22.6	76	172.6	34.3	36	231.5	46.0	96	290.3	57.7
57	55.9	11.1	17	114.8	22.8	77	173.6	34.5	37	232.4	46.2	97	291.3	57.9
58	56.9	11.3	18	115.7	23.0	78	174.6	34.7	38	233.4	46.4	98	292.3	58.1
59	57.9	11.5	19	116.7	23.2	79	175.6	34.9	39	234.4	46.6	99	293.3	58.3
60	58.8	11.7	20	117.7	23.4	80	176.5	35.1	40	235.4	46.8	300	294.2	58.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

E. by N. E. by S. W. by N. W. by S. [For 7 Points.

Digitized by Google

TABLE I.

Difference of Latitude and Departure for 1¼ Points.

N.byE.¼E.			N.byW.¼W.			S.byE.¼E.			S byW.¼W					
Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	59.2	14.8	121	117.4	29.4	181	175.6	44.0	241	233.8	58.6
2	01.9	00.5	62	60.1	15.1	22	118.3	29.6	82	176.5	44.2	42	234.7	58.8
3	02.9	00.7	63	61.1	15.3	23	119.3	29.9	83	177.5	44.5	43	235.7	59.0
4	03.9	01.0	64	62.1	15.6	24	120.3	30.1	84	178.5	44.7	44	236.7	59.3
5	04.9	01.2	65	63.1	15.8	25	121.3	30.4	85	179.5	45.0	45	237.7	59.5
6	05.8	01.5	66	64.0	16.0	26	122.2	30.6	86	180.4	45.2	46	238.6	59.8
7	06.8	01.7	67	65.0	16.3	27	123.2	30.9	87	181.4	45.4	47	239.6	60.0
8	07.8	01.9	68	66.0	16.5	28	124.2	31.1	88	182.4	45.7	48	240.6	60.3
9	08.7	02.2	69	66.9	16.8	29	125.1	31.3	89	183.3	45.9	49	241.5	60.5
10	09.7	02.4	70	67.9	17.0	30	126.1	31.6	90	184.3	46.2	50	242.5	60.7
11	10.7	02.7	71	68.9	17.3	131	127.1	31.8	191	185.3	46.4	251	243.5	61.0
12	11.6	02.9	72	69.8	17.5	32	128.0	32.1	92	186.2	46.7	52	244.4	61.2
13	12.6	03.2	73	70.8	17.7	33	129.0	32.3	93	187.2	46.9	53	245.4	61.5
14	13.6	03.4	74	71.8	18.0	34	130.0	32.6	94	188.2	47.1	54	246.4	61.7
15	14.6	03.6	75	72.8	18.2	35	131.0	32.8	95	189.2	47.4	55	247.4	62.0
16	15.5	03.9	76	73.7	18.5	36	131.9	33.0	96	190.1	47.6	56	248.3	62.2
17	16.5	04.1	77	74.7	18.7	37	132.9	33.3	97	191.1	47.9	57	249.3	62.4
18	17.5	04.4	78	75.7	19.0	38	133.9	33.5	98	192.1	48.1	58	250.3	62.7
19	18.4	04.6	79	76.6	19.2	39	134.8	33.8	99	193.0	48.4	59	251.2	62.9
20	19.4	04.9	80	77.6	19.4	40	135.8	34.0	200	194.0	48.6	60	252.2	63.2
21	20.4	05.1	81	78.6	19.7	141	136.8	34.3	201	195.0	48.8	261	253.2	63.4
22	21.3	05.3	82	79.5	19.9	42	137.7	34.5	02	195.9	49.1	62	254.1	63.7
23	22 3	05.6	83	80.5	20.2	43	138.7	34.7	03	196.9	49.3	63	255.1	63.9
24	23.3	05.8	84	81.5	20.4	44	139.7	35.0	04	197.9	49.6	64	256.1	64.1
25	24.3	06.1	85	82.5	20.7	45	140.7	35.2	05	198.9	49.8	65	257.1	64.4
26	25.2	06.3	86	83.4	20.9	46	141.6	35.5	06	199.8	50.1	66	258.0	64.6
27	26.2	06.6	87	84.4	21.1	47	142.6	35.7	07	200.8	50.3	67	259.0	64.9
28	27.2	06.8	88	85.4	21.4	48	143.6	36.0	08	201.8	50.5	68	260.0	65.1
29	28.1	07.0	89	86.3	21.6	49	144.5	36.2	09	202.7	50.8	69	260 9	65.4
30	29.1	07.3	90	87.3	21.9	50	145.5	36.4	10	203.7	51.0	70	261 9	65.6
31	30.1	07.5	91	88.3	22.1	151	146.5	36.7	211	204.7	51.3	271	262.9	65.8
32	31.0	07.8	92	89.2	22.4	52	147.4	36.9	12	205.6	51.5	72	263.8	66.1
33	32.0	08.0	93	90.2	22.6	53	148.4	37.2	13	206.6	51.8	73	264.8	66.3
34	33.0	08.3	94	91.2	22.8	54	149.4	37.4	14	207.6	52.0	74	265.8	66.6
35	34.0	08.5	95	92.2	23.1	55	150.4	37.7	15	208.6	52.2	75	266.8	66.8
36	34.9	08.7	96	93.1	23.3	56	151.3	37.9	16	209.5	52.5	76	267.7	67.1
37	35.9	09.0	97	94.1	23.6	57	152.3	38.1	17	210.5	52.7	77	268.7	67.3
38	36.9	09.2	98	95.1	23.8	58	153.3	38.4	18	211.5	53.0	78	269.7	67.5
39	37.8	09.5	99	96.0	24.1	59	154.2	38.6	19	212.4	53.2	79	270.6	67.8
40	38.8	09.7	100	97.0	24.3	60	155.2	38.9	20	213.4	53.5	80	271.6	68.0
41	39.8	10.0	101	98.0	24.5	161	156.2	39.1	221	214.4	53.7	281	272.6	68.3
42	40.7	10.2	02	98.9	24.8	62	157.1	39.4	22	215.3	53.9	82	273.5	68.5
43	41.7	10.4	03	99.9	25.0	63	158.1	39.6	23	216.3	54.2	83	274.5	68.8
44	42.7	10.7	04	100.9	25.3	64	159.1	39.8	24	217.3	54.4	84	275.5	69.0
45	43.7	10.9	05	101.9	25.5	65	160.1	40.1	25	218.3	54.7	85	276.5	69.2
46	44.6	11.2	06	102.8	25.8	66	161.0	40.3	26	219.2	54.9	86	277.4	69.5
47	45.6	11.4	07	103.8	26.0	67	162.0	40.6	27	220.2	55.2	87	278.4	69.7
48	46.6	11.7	08	104.8	26.2	68	163.0	40.8	28	221.2	55.4	88	279.4	70.0
49	47.5	11.9	09	105.7	26.5	69	163.9	41.1	29	222.1	55.6	89	280.3	70.2
50	48.5	12.1	10	106.7	26.7	70	164.9	41.3	30	223.1	55.9	90	281.3	70.5
51	49.5	12.4	111	107.7	27.0	171	165.9	41.5	231	224.1	56.1	291	282.3	70.7
52	50.4	12.6	12	108.6	27.2	72	166.8	41.8	32	225.0	56.4	92	283.2	71.0
53	51.4	12.9	13	109.6	27.5	73	167.8	42.0	33	226.0	56.6	93	284.2	71.2
54	52.4	13.1	14	110.6	27.7	74	168.8	42.3	34	227.0	56.9	94	285.2	71.4
55	53.4	13.4	15	111.6	27.9	75	169.8	42.5	35	228.0	57.1	95	286.2	71.7
56	54.3	13.6	16	112.5	28.2	76	170.7	42.8	36	228.9	57.3	96	287.1	71.9
57	55.3	13.8	17	113.5	28.4	77	171.7	43.0	37	229.9	57.6	97	288.1	72.2
58	56.3	14.1	18	114.5	28.7	78	172.7	43.3	38	230.9	57.8	98	289.1	72.4
59	57.2	14.3	19	115.4	28.9	79	173.6	43.5	39	231.8	58.1	99	290.0	72.7
60	58.2	14.6	20	116.4	29 2	80	174.6	43.7	40	232 8	58.3	300	291.0	72.9
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.
E.N.E.¾E.			E.S.E.¾E.			W.N.W.¾W.			W.S.W.¾W.			[For 6¾ Points.		

Digitized by Google

TABLE I.

Difference of Latitude and Departure for 1½ Points.

N.byE.½E.			N.byW.½W.			S.byE.½E.			S.byW.½W.		
Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.3	61	58.4	17.7	121	115.8	35.1	181	173.2	52.5	241	230.6	70.0
2	01.9	00.6	62	59.3	18.0	22	116.7	35.4	82	174.2	52.8	42	231.6	70.2
3	02.9	00.9	63	60.3	18.3	23	117.7	35.7	83	175.1	53.1	43	232.5	70.5
4	03.8	01.2	64	61.2	18.6	24	118.7	36.0	84	176.1	53.4	44	233.5	70.8
5	04.8	01.5	65	62.2	18.9	25	119.6	36.3	85	177.0	53.7	45	234.5	71.1
6	05.7	01.7	66	63.2	19.2	26	120.6	36.6	86	178.0	54.0	46	235.4	71.4
7	06.7	02.0	67	64.1	19.4	27	121.5	36.9	87	178.9	54.3	47	236.4	71.7
8	07.7	02.3	68	65.1	19.7	28	122.5	37.2	88	179.9	54.6	48	237.3	72.0
9	08.6	02.6	69	66.0	20.0	29	123.4	37.4	89	180.9	54.9	49	238.3	72.3
10	09.6	02.9	70	67.0	20.3	30	124.4	37.7	90	181.8	55.2	50	239.2	72.6
11	10.5	03.2	71	67.9	20.6	131	125.4	38.0	191	182.8	55.4	251	240.2	72.9
12	11.5	03.5	72	68.9	20.9	32	126.3	38.3	92	183.7	55.7	52	241.1	73.2
13	12.4	03.8	73	69.9	21.2	33	127.3	38.6	93	184.7	56.0	53	242.1	73.4
14	13.4	04.1	74	70.8	21.5	34	128.2	38.9	94	185.6	56.3	54	243.1	73.7
15	14.4	04.4	75	71.8	21.8	35	129.2	39.2	95	186.6	56.6	55	244.0	74.0
16	15.3	04.6	76	72.7	22.1	36	130.1	39.5	96	187.6	56.9	56	245.0	74.3
17	16.3	04.9	77	73.7	22.4	37	131.1	39.8	97	188.5	57.2	57	245.9	74.6
18	17.2	05.2	78	74.6	22.6	38	132.1	40.1	98	189.5	57.5	58	246.9	74.9
19	18.2	05.5	79	75.6	22.9	39	133.0	40.3	99	190.4	57.8	59	247.8	75.2
20	19.1	05.8	80	76.6	23.2	40	134.0	40.6	200	191.4	58.1	60	248.8	75.5
21	20.1	06.1	81	77.5	23.5	141	134.9	40.9	201	192.3	58.3	261	249.8	75.8
22	21.1	06.4	82	78.5	23.8	42	135.9	41.2	02	193.3	58.6	62	250.7	76.1
23	22.0	06.7	83	79.4	24.1	43	136.8	41.5	03	194.3	58.9	63	251.7	76.3
24	23.0	07.0	84	80.4	24.4	44	137.8	41.8	04	195.2	59.2	64	252.6	76.6
25	23.9	07.3	85	81.3	24.7	45	138.8	42.1	05	196.2	59.5	65	253.6	76.9
26	24.9	07.5	86	82.3	25.0	46	139.7	42.4	06	197.1	59.8	66	254.5	77.2
27	25.8	07.8	87	83.3	25.3	47	140.7	42.7	07	198.1	60.1	67	255.5	77.5
28	26.8	08.1	88	84.2	25.5	48	141.6	43.0	08	199.0	60.4	68	256.5	77.8
29	27.8	08.4	89	85.2	25.8	49	142.6	43.3	09	200.0	60.7	69	257.4	78.1
30	28.7	08.7	90	86.1	26.1	50	143.5	43.5	10	201.0	61.0	70	258.4	78.4
31	29.7	09.0	91	87.1	26.4	151	144.5	43.8	211	201.9	61.3	271	259.3	78.7
32	30.6	09.3	92	88.0	26.7	52	145.5	44.1	12	202.9	61.5	72	260.3	79.0
33	31.6	09.6	93	89.0	27.0	53	146.4	44.4	13	203.8	61.8	73	261.2	79.2
34	32.5	09.9	94	90.0	27.3	54	147.4	44.7	14	204.8	62.1	74	262.2	79.5
35	33.5	10.2	95	90.9	27.6	55	148.3	45.0	15	205.7	62.4	75	263.2	79.8
36	34.4	10.5	96	91.9	27.9	56	149.3	45.3	16	206.7	62.7	76	264.1	80.1
37	35.4	10.7	97	92.8	28.2	57	150.2	45.6	17	207.7	63.0	77	265.1	80.4
38	36.4	11.0	98	93.8	28.4	58	151.2	45.9	18	208.6	63.3	78	266.0	80.7
39	37.3	11.3	99	94.7	28.7	59	152.2	46.2	19	209.6	63.6	79	267.0	81.0
40	38.3	11.6	100	95.7	29.0	60	153.1	46.4	20	210.5	63.9	80	267.9	81.3
41	39.2	11.9	101	96.7	29.3	161	154.1	46.7	221	211.5	64.2	281	268.9	81.6
42	40.2	12.2	02	97.6	29.6	62	155.0	47.0	22	212.4	64.4	82	269.9	81.9
43	41.1	12.5	03	98.6	29.9	63	156.0	47.3	23	213.4	64.7	83	270.8	82.2
44	42.1	12.8	04	99.5	30.2	64	156.9	47.6	24	214.4	65.0	84	271.8	82.4
45	43.1	13.1	05	100.5	30.5	65	157.9	47.9	25	215.3	65.3	85	272.7	82.7
46	44.0	13.4	06	101.4	30.8	66	158.9	48.2	26	216.3	65.6	86	273.7	83.0
47	45.0	13.6	07	102.4	31.1	67	159.8	48.5	27	217.2	65.9	87	274.6	83.3
48	45.9	13.9	08	103.3	31.4	68	160.8	48.8	28	218.2	66.2	88	275.6	83.6
49	46.9	14.2	09	104.3	31.6	69	161.7	49.1	29	219.1	66.5	89	276.6	83.9
50	47.8	14.5	10	105.3	31.9	70	162.7	49.3	30	220.1	66.8	90	277.5	84.2
51	48.8	14.8	111	106.2	32.2	171	163.6	49.6	231	221.1	67.1	291	278.5	84.5
52	49.8	15.1	12	107.2	32.5	72	164.6	49.9	32	222.0	67.3	92	279.4	84.8
53	50.7	15.4	13	108.1	32.8	73	165.6	50.2	33	223.0	67.6	93	280.4	85.1
54	51.7	15.7	14	109.1	33.1	74	166.5	50.5	34	223.9	67.9	94	281.3	85.3
55	52.6	16.0	15	110.0	33.4	75	167.5	50.8	35	224.9	68.2	95	282.3	85.6
56	53.6	16.3	16	111.0	33.7	76	168.4	51.1	36	225.8	68.5	96	283.3	85.9
57	54.5	16.5	17	112.0	34.0	77	169.4	51.4	37	226.8	68.8	97	284.2	86.2
58	55.5	16.8	18	112.9	34.3	78	170.3	51.7	38	227.8	69.1	98	285.2	86.5
59	56.5	17.1	19	113.9	34.5	79	171.3	52.0	39	228.7	69.4	99	286.1	86.8
60	57.4	17.4	10	114.8	34.8	80	172.2	52.3	40	229.7	69.7	300	287.1	87.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.
E.N.E.½E.			E.S.E.½E.			W.N.W.½W.			W.S.W.½W.			[For 6½ Points.		

Digitized by Google

TABLE I.

Difference of Latitude and Departure for 1¾ Points.

N.by E.¾E. | N.by W.¾W. | S.by E.¾E. | S.by W.¾W.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.3	61	57.4	20.6	121	113.9	40.8	181	170.4	61.0	241	226.9	81.2
2	01.9	00.7	62	58.4	20.9	22	114.9	41.1	82	171.4	61.3	42	227.9	81.5
3	02.8	01.0	63	59.3	21.2	23	115.8	41.4	83	172.3	61.7	43	228.8	81.9
4	03.8	01.3	64	60.3	21.6	24	116.8	41.8	84	173.2	62.0	44	229.7	82.2
5	04.7	01.7	65	61.2	21.9	25	117.7	42.1	85	174.2	62.3	45	230.7	82.5
6	05.6	02.0	66	62.1	22.2	26	118.6	42.4	86	175.1	62.7	46	231.6	82.9
7	06.6	02.4	67	63.1	22.6	27	119.6	42.8	87	176.1	63.0	47	232.6	83.2
8	07.5	02.7	68	64.0	22.9	28	120.5	43.1	88	177.0	63.3	48	233.5	83.5
9	08.5	03.0	69	65.0	23.2	29	121.5	43.5	89	178.0	63.7	49	234.4	83.9
10	09.4	03.4	70	65.9	23.6	30	122.4	43.8	90	178.9	64.0	50	235.4	84.2
11	10.4	03.7	71	66.8	23.9	131	123.3	44.1	191	179.8	64.3	251	236.3	84.6
12	11.3	04.0	72	67.8	24.3	32	124.3	44.5	92	180.8	64.7	52	237.3	84.9
13	12.2	04.4	73	68.7	24.6	33	125.2	44.8	93	181.7	65.0	53	238.2	85.2
14	13.2	04.7	74	69.7	24.9	34	126.2	45.1	94	182.7	65.4	54	239.2	85.6
15	14.1	05.1	75	70.6	25.3	35	127.1	45.5	95	183.6	65.7	55	240.1	85.9
16	15.1	05.4	76	71.6	25.6	36	128.0	45.8	96	184.5	66.0	56	241.0	86.2
17	16.0	05.7	77	72.5	25.9	37	129.0	46.2	97	185.5	66.4	57	242.0	86.6
18	16.9	06.1	78	73.4	26.3	38	129.9	46.5	98	186.4	66.7	58	242.9	86.9
19	17.9	06.4	79	74.4	26.6	39	130.9	46.8	99	187.4	67.0	59	243.9	87.3
20	18.8	06.7	80	75.3	27.0	40	131.8	47.2	200	188.3	67.4	60	244.8	87.6
21	19.8	07.1	81	76.3	27.3	141	132.8	47.5	201	189.3	67.7	261	245.7	87.9
22	20.7	07.4	82	77.2	27.6	42	133.7	47.8	02	190.2	68.1	62	246.7	88.3
23	21.7	07.7	83	78.1	28.0	43	134.6	48.2	03	191.1	68.4	63	247.6	88.6
24	22.6	08.1	84	79.1	28.3	44	135.6	48.5	04	192.1	68.7	64	248.6	88.9
25	23.5	08.4	85	80.0	28.6	45	136.5	48.8	05	193.0	69.1	65	249.5	89.3
26	24.5	08.8	86	81.0	29.0	46	137.5	49.2	06	194.0	69.4	66	250.5	89.6
27	25.4	09.1	87	81.9	29.3	47	138.4	49.5	07	194.9	69.7	67	251.4	89.9
28	26.4	09.4	88	82.9	29.6	48	139.3	49.9	08	195.8	70.1	68	252.3	90.3
29	27.3	09.8	89	83.8	30.0	49	140.3	50.2	09	196.8	70.4	69	253.3	90.6
30	28.2	10.1	90	84.7	30.3	50	141.2	50.5	10	197.7	70.7	70	254.2	91.0
31	29.2	10.4	91	85.7	30.7	151	142.2	50.9	211	198.7	71.1	271	255.2	91.3
32	30.1	10.8	92	86.6	31.0	52	143.1	51.2	12	199.6	71.4	72	256.1	91.6
33	31.1	11.1	93	87.6	31.3	53	144.1	51.5	13	200.5	71.8	73	257.0	92.0
34	32.0	11.5	94	88.5	31.7	54	145.0	51.9	14	201.5	72.1	74	258.0	92.3
35	33.0	11.8	95	89.4	32.0	55	145.9	52.2	15	202.4	72.4	75	258.9	92.6
36	33.9	12.1	96	90.4	32.3	56	146.9	52.6	16	203.4	72.8	76	259.9	93.0
37	34.8	12.5	97	91.3	32.7	57	147.8	52.9	17	204.3	73.1	77	260.8	93.3
38	35.8	12.8	98	92.3	33.0	58	148.8	53.2	18	205.3	73.4	78	261.7	93.7
39	36.7	13.1	99	93.2	33.4	59	149.7	53.6	19	206.2	73.8	79	262.7	94.0
40	37.7	13.5	100	94.2	33.7	60	150.6	53.9	20	207.1	74.1	80	263.6	94.3
41	38.6	13.8	101	95.1	34.0	161	151.6	54.2	221	208.1	74.5	281	264.6	94.7
42	39.5	14.1	02	96.0	34.4	62	152.5	54.6	22	209.0	74.8	82	265.5	95.0
43	40.5	14.5	03	97.0	34.7	63	153.5	54.9	23	210.0	75.1	83	266.5	95.3
44	41.4	14.8	04	97.9	35.0	64	154.4	55.2	24	210.9	75.5	84	267.4	95.7
45	42.4	15.2	05	98.9	35.4	65	155.4	55.6	25	211.8	75.8	85	268.3	96.0
46	43.3	15.5	06	99.8	35.7	66	156.3	55.9	26	212.8	76.1	86	269.3	96.4
47	44.3	15.8	07	100.7	36.0	67	157.2	56.3	27	213.7	76.5	87	270.2	96.7
48	45.2	16.2	08	101.7	36.4	68	158.2	56.6	28	214.7	76.8	88	271.2	97.0
49	46.1	16.5	09	102.6	36.7	69	159.1	56.9	29	215.6	77.1	89	272.1	97.4
50	47.1	16.8	10	103.6	37.1	70	160.1	57.3	30	216.6	77.5	90	273.0	97.7
51	48.0	17.2	111	104.5	37.4	171	161.0	57.6	231	217.5	77.8	291	274.0	98.0
52	49.0	17.5	12	105.5	37.7	72	161.9	57.9	32	218.4	78.2	92	274.9	98.4
53	49.9	17.9	13	106.4	38.1	73	162.9	58.3	33	219.4	78.5	93	275.9	98.7
54	50.8	18.2	14	107.3	38.4	74	163.8	58.6	34	220.3	78.8	94	276.8	99.0
55	51.8	18.5	15	108.3	38.7	75	164.8	59.0	35	221.3	79.2	95	277.8	99.4
56	52.7	18.9	16	109.2	39.1	76	165.7	59.3	36	222.2	79.5	96	278.7	99.7
57	53.7	19.2	17	110.2	39.4	77	166.7	59.6	37	223.1	79.8	97	279.6	100.1
58	54.6	19.5	18	111.1	39.8	78	167.6	60.0	38	224.1	80.2	98	280.6	100.4
59	55.6	19.9	19	112.0	40.1	79	168.5	60.3	39	225.0	80.5	99	281.5	100.7
60	56.5	20.2	20	113.0	40.4	80	169.5	60.6	40	226.0	80.9	300	282.5	101.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

E.N.E.¼E. | E.S.E.¼E. | W.N.W.¼W. | W.S.W.¼W. | [For 6¼ Points.

Digitized by Google

TABLE I

Difference of Latitude and Departure for 2 Points.

N.N.E. N.N.W. S.S.E. S.S.W.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	56.4	23.3	121	111.8	46.3	181	167.2	69.3	241	222.7	92.2
2	01.8	00.8	62	57.3	23.7	22	112.7	46.7	82	168.1	69.6	42	223.6	92.6
3	02.8	01.1	63	58.2	24.1	23	113.6	47.1	83	169.1	70.0	43	224.5	93.0
4	03.7	01.5	64	59.1	24.5	24	114.6	47.5	84	170.0	70.4	44	225.4	93.4
5	04.6	01.9	65	60.1	24.9	25	115.5	47.8	85	170.9	70.8	45	226.4	93.8
6	05.5	02.3	66	61.0	25.3	26	116.4	48.2	86	171.8	71.2	46	227.3	94.1
7	06.5	02.7	67	61.9	25.6	27	117.3	48.6	87	172.8	71.6	47	228.2	94.5
8	07.4	03.1	68	62.8	26.0	28	118.3	49.0	88	173.7	71.9	48	229.1	94.9
9	08.3	03.4	69	63.7	26.4	29	119.2	49.4	89	174.6	72.3	49	230.0	95.3
10	09.2	03.8	70	64.7	26.8	30	120.1	49.7	90	175.5	72.7	50	231.0	95.7
11	10.2	04.2	71	65.6	27.2	131	121.0	50.1	191	176.5	73.1	251	231.9	96.1
12	11.1	04.6	72	66.5	27.6	32	122.0	50.5	92	177.4	73.5	52	232.8	96.4
13	12.0	05.0	73	67.4	27.9	33	122.9	50.9	93	178.3	73.9	53	233.7	96.8
14	12.9	05.4	74	68.4	28.3	34	123.8	51.3	94	179.2	74.2	54	234.7	97.2
15	13.9	05.7	75	69.3	28.7	35	124.7	51.7	95	180.2	74.6	55	235.6	97.6
16	14.8	06.1	76	70.2	29.1	36	125.6	52.0	96	181.1	75.0	56	236.5	98.0
17	15.7	06.5	77	71.1	29.5	37	126.6	52.4	97	182.0	75.4	57	237.4	98.3
18	16.6	06.9	78	72.1	29.8	38	127.5	52.8	98	182.9	75.8	58	238.4	98.7
19	17.6	07.3	79	73.0	30.2	39	128.4	53.2	99	183.9	76.2	59	239.3	99.1
20	18.5	07.7	80	73.9	30.6	40	129.3	53.6	200	184.8	76.5	60	240.2	99.5
21	19.4	08.0	81	74.8	31.0	141	130.3	54.0	201	185.7	76.9	261	241.1	99.9
22	20.3	08.4	82	75.8	31.4	42	131.2	54.3	02	186.6	77.3	62	242.1	100.3
23	21.2	08.8	83	76.7	31.8	43	132.1	54.7	03	187.5	77.7	63	243.0	100.6
24	22.2	09.2	84	77.6	32.1	44	133.0	55.1	04	188.5	78.1	64	243.9	101.0
25	23.1	09.6	85	78.5	32.5	45	134.0	55.5	05	189.4	78.5	65	244.8	101.4
26	24.0	09.9	86	79.5	32.9	46	134.9	55.9	06	190.3	78.8	66	245.8	101.8
27	24.9	10.3	87	80.4	33.3	47	135.8	56.3	07	191.2	79.2	67	246.7	102.2
28	25.9	10.7	88	81.3	33.7	48	136.7	56.6	08	192.2	79.6	68	247.6	102.6
29	26.8	11.1	89	82.2	34.1	49	137.7	57.0	09	193.1	80.0	69	248.5	102.9
30	27.7	11.5	90	83.1	34.4	50	138.6	57.4	10	194.0	80.4	70	249.4	103.3
31	28.6	11.9	91	84.1	34.8	151	139.5	57.8	211	194.9	80.7	271	250.4	103.7
32	29.6	12.2	92	85.0	35.2	52	140.4	58.2	12	195.9	81.1	72	251.3	104.1
33	30.5	12.6	93	85.9	35.6	53	141.4	58.6	13	196.8	81.5	73	252.2	104.5
34	31.4	13.0	94	86.8	36.0	54	142.3	58.9	14	197.7	81.9	74	253.1	104.9
35	32.3	13.4	95	87.8	36.4	55	143.2	59.3	15	198.6	82.3	75	254.1	105.2
36	33.3	13.8	96	88.7	36.7	56	144.1	59.7	16	199.6	82.7	76	255.0	105.6
37	34.2	14.2	97	89.6	37.1	57	145.0	60.1	17	200.5	83.0	77	255.9	106.0
38	35.1	14.5	98	90.5	37.5	58	146.0	60.5	18	201.4	83.4	78	256.8	106.4
39	36.0	14.9	99	91.5	37.9	59	146.9	60.8	19	202.3	83.8	79	257.8	106.8
40	37.0	15.3	100	92.4	38.3	60	147.8	61.2	20	203.3	84.2	80	258.7	107.2
41	37.9	15.7	101	93.3	38.7	161	148.7	61.6	221	204.2	84.6	281	259.6	107.5
42	38.8	16.1	02	94.2	39.0	62	149.7	62.0	22	205.1	85.0	82	260.5	107.9
43	39.7	16.5	03	95.2	39.4	63	150.6	62.4	23	206.0	85.3	83	261.5	108.3
44	40.7	16.8	04	96.1	39.8	64	151.5	62.8	24	206.9	85.7	84	262.4	108.7
45	41.6	17.2	05	97.0	40.2	65	152.4	63.1	25	207.9	86.1	85	263.3	109.1
46	42.5	17.6	06	97.9	40.6	66	153.4	63.5	26	208.8	86.5	86	264.2	109.4
47	43.4	18.0	07	98.9	40.9	67	154.3	63.9	27	209.7	86.9	87	265.2	109.8
48	44.3	18.4	08	99.8	41.3	68	155.2	64.3	28	210.6	87.3	88	266.1	110.2
49	45.3	18.8	09	100.7	41.7	69	156.1	64.7	29	211.6	87.6	89	267.0	110.6
50	46.2	19.1	10	101.6	42.1	70	157.1	65.1	30	212.5	88.0	90	267.9	111.0
51	47.1	19.5	111	102.6	42.5	171	158.0	65.4	231	213.4	88.4	291	268.8	111.4
52	48.0	19.9	12	103.5	42.9	72	158.9	65.8	32	214.3	88.8	92	269.8	111.7
53	49.0	20.3	13	104.4	43.2	73	159.8	66.2	33	215.3	89.2	93	270.7	112.1
54	49.9	20.7	14	105.3	43.6	74	160.8	66.6	34	216.2	89.5	94	271.6	112.5
55	50.8	21.0	15	106.2	44.0	75	161.7	67.0	35	217.1	89.9	95	272.5	112.9
56	51.7	21.4	16	107.2	44.4	76	162.6	67.4	36	218.0	90.3	96	273.5	113.3
57	52.7	21.8	17	108.1	44.8	77	163.5	67.7	37	219.0	90.7	97	274.4	113.7
58	53.6	22.2	18	109.0	45.2	78	164.5	68.1	38	219.9	91.1	98	275.3	114.0
59	54.5	22.6	19	109.9	45.5	79	165.4	68.5	39	220.8	91.5	99	276.2	114.4
60	55.4	23.0	20	110.9	45.9	80	166.3	68.9	40	221.7	91.8	300	277.2	114.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

E.N.E. E.S.E. W.N.W. W.S.W. [For 6 Points.

Digitized by Google

TABLE I.

Difference of Latitude and Departure for 2¼ Points.

N.N.E.¼E. N.N.W.¼W. S.S.E.¼E. S.S.W.¼W.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	55.1	26.1	121	109.4	51.7	181	163.6	77.4	241	217.9	103.0
2	01.8	00.9	62	56.0	26.5	22	110.3	52.2	82	164.5	77.8	42	218.8	103.5
3	02.7	01.3	63	57.0	26.9	23	111.2	52.6	83	165.4	78.2	43	219.7	103.9
4	03.6	01.7	64	57.9	27.4	24	112.1	53.0	84	166.3	78.7	44	220.6	104.3
5	04.5	02.1	65	58.8	27.8	25	113.0	53.4	85	167.2	79.1	45	221.5	104.8
6	05.4	02.6	66	59.7	28.2	26	113.9	53.9	86	168.1	79.5	46	222.4	105.2
7	06.3	03.0	67	60.6	28.6	27	114.8	54.3	87	169.0	80.0	47	223.3	105.6
8	07.2	03.4	68	61.5	29.1	28	115.7	54.7	88	169.9	80.4	48	224.2	106.0
9	08.1	03.8	69	62.4	29.5	29	116.6	55.2	89	170.9	80.8	49	225.1	106.5
10	09.0	04.3	70	63.3	29.9	30	117.5	55.6	90	171.8	81.2	50	226.0	106.9
11	09.9	04.7	71	64.2	30.4	131	118.4	56.0	191	172.7	81.7	251	226.9	107.3
12	10.8	05.1	72	65.1	30.8	32	119.3	56.4	92	173.6	82.1	52	227.8	107.7
13	11.8	05.6	73	66.0	31.2	33	120.2	56.9	93	174.5	82.5	53	228.7	108.2
14	12.7	06.0	74	66.9	31.6	34	121.1	57.3	94	175.4	82.9	54	229.6	108.6
15	13.6	06.4	75	67.8	32.1	35	122.0	57.7	95	176.3	83.4	55	230.5	109.0
16	14.5	06.8	76	68.7	32.5	36	122.9	58.1	96	177.2	83.8	56	231.4	109.5
17	15.4	07.3	77	69.6	32.9	37	123.8	58.6	97	178.1	84.2	57	232.3	109.9
18	16.3	07.7	78	70.5	33.3	38	124.8	59.0	98	179.0	84.7	58	233.2	110.3
19	17.2	08.1	79	71.4	33.8	39	125.7	59.4	99	179.9	85.1	59	234.1	110.7
20	18.1	08.6	80	72.3	34.2	40	126.6	59.9	200	180.8	85.5	60	235.0	111.2
21	19.0	09.0	81	73.2	34.6	141	127.5	60.3	201	181.7	85.9	261	235.9	111.6
22	19.9	09.4	82	74.1	35.1	42	128.4	60.7	02	182.6	86.4	62	236.8	112.0
23	20.8	09.8	83	75.0	35.5	43	129.3	61.1	03	183.5	86.8	63	237.7	112.4
24	21.7	10.3	84	75.9	35.9	44	130.2	61.6	04	184.4	87.2	64	238.7	112.9
25	22.6	10.7	85	76.8	36.3	45	131.1	62.0	05	185.3	87.6	65	239.6	113.3
26	23.5	11.1	86	77.7	36.8	46	132.0	62.4	06	186.2	88.1	66	240.5	113.7
27	24.4	11.5	87	78.6	37.2	47	132.9	62.9	07	187.1	88.5	67	241.4	114.2
28	25.3	12.0	88	79.6	37.6	48	133.8	63.3	08	188.0	88.9	68	242.3	114.6
29	26.2	12.4	89	80.5	38.1	49	134.7	63.7	09	188.9	89.4	69	243.2	115.0
30	27.1	12.8	90	81.4	38.5	50	135.6	64.1	10	189.8	89.8	70	244.1	115.4
31	28.0	13.3	91	82.3	38.9	151	136.5	64.6	211	190.7	90.2	271	245.0	115.9
32	28.9	13.7	92	83.2	39.3	52	137.4	65.0	12	191.6	90.6	72	245.9	116.3
33	29.8	14.1	93	84.1	39.8	53	138.3	65.4	13	192.5	91.1	73	246.8	116.7
34	30.7	14.5	94	85.0	40.2	54	139.2	65.8	14	193.5	91.5	74	247.7	117.2
35	31.6	15.0	95	85.9	40.6	55	140.1	66.3	15	194.4	91.9	75	248.6	117.6
36	32.5	15.4	96	86.8	41.0	56	141.0	66.7	16	195.3	92.4	76	249.5	118.0
37	33.4	15.8	97	87.7	41.5	57	141.9	67.1	17	196.2	92.8	77	250.4	118.4
38	34.4	16.2	98	88.6	41.9	58	142.8	67.6	18	197.1	93.2	78	251.3	118.9
39	35.3	16.7	99	89.5	42.3	59	143.7	68.0	19	198.0	93.6	79	252.2	119.3
40	36.2	17.1	100	90.4	42.8	60	144.6	68.4	20	198.9	94.1	80	253.1	119.7
41	37.1	17.5	101	91.3	43.2	161	145.5	68.8	221	199.8	94.5	281	254.0	120.1
42	38.0	18.0	02	92.2	43.6	62	146.4	69.3	22	200.7	94.9	82	254.9	120.6
43	38.9	18.4	03	93.1	44.0	63	147.4	69.7	23	201.6	95.3	83	255.8	121.0
44	39.8	18.8	04	94.0	44.5	64	148.3	70.1	24	202.5	95.8	84	256.7	121.4
45	40.7	19.2	05	94.9	44.9	65	149.2	70.5	25	203.4	96.2	85	257.6	121.9
46	41.6	19.7	06	95.8	45.3	66	150.1	71.0	26	204.3	96.6	86	258.5	122.3
47	42.5	20.1	07	96.7	45.7	67	151.0	71.4	27	205.2	97.1	87	259.4	122.7
48	43.4	20.5	08	97.6	46.2	68	151.9	71.8	28	206.1	97.5	88	260.3	123.1
49	44.3	21.0	09	98.5	46.6	69	152.8	72.3	29	207.0	97.9	89	261.3	123.6
50	45.2	21.4	10	99.4	47.0	70	153.7	72.7	30	207.9	98.3	90	262.2	124.0
51	46.1	21.8	111	100.3	47.5	171	154.6	73.1	231	208.8	98.8	291	263.1	124.4
52	47.0	22.2	12	101.2	47.9	72	155.5	73.5	32	209.7	99.2	92	264.0	124.8
53	47.9	22.7	13	102.2	48.3	73	156.4	74.0	33	210.6	99.6	93	264.9	125.3
54	48.8	23.1	14	103.1	48.7	74	157.3	74.4	34	211.5	100.0	94	265.8	125.7
55	49.7	23.5	15	104.0	49.2	75	158.2	74.8	35	212.4	100.5	95	266.7	126.1
56	50.6	23.9	16	104.9	49.6	76	159.1	75.2	36	213.3	100.9	96	267.6	126.6
57	51.5	24.4	17	105.8	50.0	77	160.0	75.7	37	214.2	101.3	97	268.5	127.0
58	52.4	24.8	18	106.7	50.5	78	160.9	76.1	38	215.1	101.8	98	269.4	127.4
59	53.3	25.2	19	107.6	50.9	79	161.8	76.5	39	216.1	102.2	99	270.3	127.8
60	54.2	25.7	20	108.5	51.3	80	162.7	77.0	40	217.0	102.6	300	271.2	128.3
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

N.E.byE.¾E. S.E.byE.¾E. N.W.byW.¾W. S.W.byW.¾W. [For 5¾ Points.

Digitized by Google

TABLE I.

Difference of Latitude and Departure for 2¼ Points.

N.N.E.¼E. N.N.W.¼W. S.S.E.¼E. S.S.W.¼W.

Dist.	Lat.	Dep.	Dist	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.5	61	53.8	28.8	121	106.7	57.0	181	159.6	85.3	241	212.5	113.6
2	01.8	00.9	62	54.7	29.2	22	107.6	57.5	82	160.5	85.8	42	213.4	114.1
3	02.6	01.4	63	55.0	29.7	23	108.5	58.0	83	161.4	86.3	43	214.3	114.5
4	03.5	01.9	64	56.4	30.2	24	109.4	58.5	84	162.3	86.7	44	215.2	115.0
5	04.4	02.4	65	57.3	30.6	25	110.2	58.9	85	163.2	87.2	45	216.1	115.5
6	05.3	02.8	66	58.2	31.1	26	111.1	59.4	86	164.0	87.7	46	217.0	116.0
7	06.2	03.3	67	59.1	31.6	27	112.0	59.9	87	164.9	88.2	47	217.8	116.4
8	07.1	03.8	68	60.0	32.1	28	112.9	60.3	88	165.8	88.6	48	218.7	116.9
9	07.9	04.2	69	60.9	32.5	29	113.8	60.8	89	166.7	89.1	49	219.6	117.4
10	08.8	04.7	70	61.7	33.0	30	114.6	61.3	90	167.6	89.6	50	220.5	117.8
11	09.7	05.2	71	62.6	33.5	131	115.5	61.8	191	168.4	90.0	251	221.4	118.3
12	10.6	05.7	72	63.5	33.9	32	116.4	62.2	92	169.3	90.5	52	222.2	118.8
13	11.5	06.1	73	64.4	34.4	33	117.3	62.7	93	170.2	91.0	53	223.1	119.3
14	12.3	06.6	74	65.3	34.9	34	118.2	63.2	94	171.1	91.5	54	224.0	119.7
15	13.2	07.1	75	66.1	35.4	35	119.1	63.6	95	172.0	91.9	55	224.9	120.2
16	14.1	07.5	76	67.0	35.8	36	119.9	64.1	96	172.9	92.4	56	225.8	120.7
17	15.0	08.0	77	67.9	36.3	37	120.8	64.6	97	173.7	92.9	57	226.7	121.1
18	15.9	08.5	78	68.8	36.8	38	121.7	65.1	98	174.6	93.3	58	227.5	121.6
19	16.8	09.0	79	69.7	37.2	39	122.6	65.5	99	175.5	93.8	59	228.4	122.1
20	17.6	09.4	80	70.6	37.7	40	123.5	66.0	200	176.4	94.3	60	229.3	122.6
21	18.5	09.9	81	71.4	38.2	141	124.4	66.5	201	177.3	94.8	261	230.2	123.0
22	19.4	10.4	82	72.3	38.7	42	125.2	66.9	02	178.1	95.2	62	231.1	123.5
23	20.3	10.8	83	73.2	39.1	43	126.1	67.4	03	179.0	95.7	63	231.9	124.0
24	21.2	11.3	84	74.1	39.6	44	127.0	67.9	04	179.9	96.2	64	232.8	124.4
25	22.0	11.8	85	75.0	40.1	45	127.9	68.4	05	180.8	96.6	65	233.7	124.9
26	22.9	12.3	86	75.8	40.5	46	128.8	68.8	06	181.7	97.1	66	234.6	125.4
27	23.8	12.7	87	76.7	41.0	47	129.6	69.3	07	182.6	97.6	67	235.5	125.9
28	24.7	13.2	88	77.6	41.5	48	130.5	69.8	08	183.4	98.1	68	236.4	126.3
29	25.6	13.7	89	78.5	42.0	49	131.4	70.2	09	184.3	98.5	69	237.2	126.8
30	26.5	14.1	90	79.4	42.4	50	132.3	70.7	10	185.2	99.0	70	238.1	127.3
31	27.3	14.6	91	80.3	42.9	151	133.2	71.2	211	186.1	99.5	271	239.0	127.7
32	28.2	15.1	92	81.1	43.4	52	134.1	71.7	12	187.0	99.9	72	239.9	128.2
33	29.1	15.6	93	82.0	43.8	53	134.9	72.1	13	187.8	100.4	73	240.8	128.7
34	30.0	16.0	94	82.9	44.3	54	135.8	72.6	14	188.7	100.9	74	241.6	129.2
35	30.9	16.5	95	83.8	44.8	55	136.7	73.1	15	189.6	101.4	75	242.5	129.6
36	31.7	17.0	96	84.7	45.3	56	137.6	73.5	16	190.5	101.8	76	243.4	130.1
37	32.6	17.4	97	85.5	45.7	57	138.5	74.0	17	191.4	102.3	77	244.3	130.6
38	33.5	17.9	98	86.4	46.2	58	139.3	74.5	18	192.3	102.8	78	245.2	131.0
39	34.4	18.4	99	87.3	46.7	59	140.2	75.0	19	193.1	103.2	79	246.1	131.5
40	35.3	18.9	100	88.2	47.1	60	141.1	75.4	20	194.0	103.7	80	246.9	132.0
41	36.2	19.3	101	89.1	47.6	161	142.0	75.9	221	194.9	104.2	281	247.8	132.5
42	37.0	19.8	02	90.0	48.1	62	142.9	76.4	22	195.8	104.7	82	248.7	132.9
43	37.9	20.3	03	90.8	48.6	63	143.8	76.8	23	196.7	105.1	83	249.6	133.4
44	38.8	20.7	04	91.7	49.0	64	144.6	77.3	24	197.6	105.6	84	250.5	133.9
45	39.7	21.2	05	92.6	49.5	65	145.5	77.8	25	198.4	106.1	85	251.3	134.3
46	40.6	21.7	06	93.5	50.0	66	146.4	78.3	26	199.3	106.5	86	252.2	134.8
47	41.5	22.2	07	94.4	50.4	67	147.3	78.7	27	200.2	107.0	87	253.1	135.3
48	42.3	22.6	08	95.2	50.9	68	148.2	79.2	28	201.1	107.5	88	254.0	135.8
49	43.2	23.1	09	96.1	51.4	69	149.0	79.7	29	202.0	107.9	89	254.9	136.2
50	44.1	23.6	10	97.0	51.9	70	149.9	80.1	30	202.8	108.4	90	255.8	136.7
51	45.0	24.0	111	97.9	52.3	171	150.8	80.6	231	203.7	108.9	291	256.6	137.2
52	45.9	24.5	12	98.8	52.8	72	151.7	81.1	32	204.6	109.4	92	257.5	137.6
53	46.7	25.0	13	99.7	53.3	73	152.6	81.6	33	205.5	109.8	93	258.4	138.1
54	47.6	25.5	14	100.5	53.7	74	153.5	82.0	34	206.4	110.3	94	259.3	138.6
55	48.5	25.9	15	101.4	54.2	75	154.3	82.5	35	207.3	110.8	95	260.2	139.1
56	49.4	26.4	16	102.3	54.7	76	155.2	83.0	36	208.1	111.2	96	261.0	139.5
57	50.3	26.9	17	103.2	55.2	77	156.1	83.4	37	209.0	111.7	97	261.9	140.0
58	51.2	27.3	18	104.1	55.6	78	157.0	83.9	38	209.9	112.2	98	262.8	140.5
59	52.0	27.8	19	104.9	56.1	79	157.9	84.4	39	210.8	112.7	99	263.7	140.9
60	52.9	28.3	20	105.8	56.6	80	158.7	84.9	40	211.7	113.1	300	264.6	141.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

N.E.byE.¾E. S.E.byE.¾E. N.W.byW.¾W. S.W.byW.¾W.

Digitized by Google

TABLE I.

Difference of Latitude and Departure for 2¾ Points.

N.N.E.¾E.			N.N.W.¾W.			S.S.E.¾E.			S.S.W.¾W.					
Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.5	61	52.3	31.4	121	103.8	62.2	181	155.2	93.1	241	206.7	123.9
2	01.7	01.0	62	53.2	31.9	22	104.6	62.7	82	156.1	93.6	42	207.6	124.4
3	02.6	01.5	63	54.0	32.4	23	105.5	63.2	83	157.0	94.1	43	208.4	124.9
4	03.4	02.1	64	54.9	32.9	24	106.4	63.7	84	157.8	94.6	44	209.3	125.4
5	04.3	02.6	65	55.8	33.4	25	107.2	64.3	85	158.7	95.1	45	210.1	126.0
6	05.1	03.1	66	56.6	33.9	26	108.1	64.8	86	159.5	95.6	46	211.0	126.5
7	06.0	03.6	67	57.5	34.4	27	108.9	65.3	87	160.4	96.1	47	211.9	127.0
8	06.9	04.1	68	58.3	35.0	28	109.8	65.8	88	161.3	96.7	48	212.7	127.5
9	07.7	04.6	69	59.2	35.5	29	110.6	66.3	89	162.1	97.2	49	213.6	128.0
10	08.6	05.1	70	60.0	36.0	30	111.5	66.8	90	163.0	97.7	50	214.4	128.5
11	09.4	05.7	71	60.9	36.5	131	112.4	67.3	191	163.8	98.2	251	215.3	129.0
12	10.3	06.2	72	61.8	37.0	32	113.2	67.9	92	164.7	98.7	52	216.1	129.6
13	11.2	06.7	73	62.6	37.5	33	114.1	68.4	93	165.5	99.2	53	217.0	130.1
14	12.0	07.2	74	63.5	38.0	34	114.9	68.9	94	166.4	99.7	54	217.9	130.6
15	12.9	07.7	75	64.3	38.6	35	115.8	69.4	95	167.3	100.3	55	218.7	131.1
16	13.7	08.2	76	65.2	39.1	36	116.7	69.9	96	168.1	100.8	56	219.6	131.6
17	14.6	08.7	77	66.0	39.6	37	117.5	70.4	97	169.0	101.3	57	220.4	132.1
18	15.4	09.3	78	66.9	40.1	38	118.4	70.9	98	169.8	101.8	58	221.3	132.6
19	16.3	09.8	79	67.8	40.6	39	119.2	71.5	99	170.7	102.3	59	222.2	133.2
20	17.2	10.3	80	68.6	41.1	40	120.1	72.0	200	171.5	102.8	60	223.0	133.7
21	18.0	10.8	81	69.5	41.6	141	120.9	72.5	201	172.4	103.3	261	223.9	134.2
22	18.9	11.3	82	70.3	42.2	42	121.8	73.0	02	173.3	103.8	62	224.7	134.7
23	19.7	11.8	83	71.2	42.7	43	122.7	73.5	03	174.1	104.4	63	225.6	135.2
24	20.6	12.3	84	72.0	43.2	44	123.5	74.0	04	175.0	104.9	64	226.4	135.7
25	21.4	12.9	85	72.9	43.7	45	124.4	74.5	05	175.8	105.4	65	227.3	136.2
26	22.3	13.4	86	73.8	44.2	46	125.2	75.1	06	176.7	105.9	66	228.2	136.8
27	23.2	13.9	87	74.6	44.7	47	126.1	75.6	07	177.5	106.4	67	229.0	137.3
28	24.0	14.4	88	75.5	45.2	48	126.9	76.1	08	178.4	106.9	68	229.9	137.8
29	24.9	14.9	89	76.3	45.8	49	127.8	76.6	09	179.3	107.4	69	230.7	138.3
30	25.7	15.4	90	77.2	46.3	50	128.7	77.1	10	180.1	108.0	70	231.6	138.8
31	26.6	15.9	91	78.1	46.8	151	129.5	77.6	211	181.0	108.5	271	232.4	139.3
32	27.4	16.5	92	78.9	47.3	52	130.4	78.1	12	181.8	109.0	72	233.3	139.8
33	28.3	17.0	93	79.8	47.8	53	131.2	78.7	13	182.7	109.5	73	234.2	140.4
34	29.2	17.5	94	80.6	48.3	54	132.[illegible]	79.2	14	183.6	110.0	74	235.0	140.9
35	30.0	18.0	95	81.5	48.8	55	132.9	79.7	15	184.4	110.5	75	235.9	141.4
36	30.9	18.5	96	82.3	49.4	56	133.8	80.2	16	185.3	111.0	76	236.7	141.9
37	31.7	19.0	97	83.2	49.9	57	134.7	80.7	17	186.1	111.6	77	237.6	142.4
38	32.6	19.5	98	84.1	50.4	58	135.5	81.2	18	187.0	112.1	78	238.4	142.9
39	33.5	20.1	99	84.9	50.9	59	136.4	81.7	19	187.8	112.6	79	239.3	143.4
40	34.3	20.6	100	85.8	51.4	60	137.2	82.3	20	188.7	113.1	80	240.2	143.9
41	35.2	21.1	101	86.6	51.9	161	138.1	82.8	221	189.6	113.6	261	241.0	144.5
42	36.0	21.6	02	87.5	52.4	62	139.0	83.3	22	190.4	114.1	82	241.9	145.0
43	36.9	22.1	03	88.3	53.0	63	139.8	83.8	23	191.3	114.6	83	242.7	145.5
44	37.7	22.6	04	89.2	53.5	64	140.7	84.3	24	192.1	115.2	84	243.6	146.0
45	38.6	23.1	05	90.1	54.0	65	141.5	84.8	25	193.0	115.7	85	244.5	146.5
46	39.5	23.6	06	90.9	54.5	66	142.4	85.3	26	193.8	116.2	86	245.3	147.0
47	40.3	24.2	07	91.8	55.0	67	143.2	85.9	27	194.7	116.7	87	246.2	147.5
48	41.2	24.7	08	92.6	55.5	68	144.1	86.4	28	195.6	117.2	88	247.0	148.1
49	42.0	25.2	09	93.5	56.0	69	145.0	86.9	29	196.4	117.7	89	247.9	148.6
50	42.9	25.7	10	94.4	56.6	70	145.8	87.4	30	197.3	118.2	90	248.7	149.1
51	43.7	26.2	111	95.2	57.1	171	146.7	87.9	231	198.1	118.8	291	249.6	149.6
52	44.6	26.7	12	96.1	57.6	72	147.5	88.4	32	199.0	119.3	92	250.5	150.1
53	45.5	27.2	13	96.9	58.1	73	148.4	88.9	33	199.9	119.8	93	251.3	150.6
54	46.3	27.8	14	97.8	58.6	74	149.2	89.5	34	200.7	120.3	94	252.2	151.1
55	47.2	28.3	15	98.6	59.1	75	150.1	90.0	35	201.6	120.8	95	253.0	151.7
56	48.0	28.8	16	99.5	59.6	76	151.0	90.5	36	202.4	121.3	96	253.9	152.2
57	48.9	29.3	17	100.4	60.2	77	151.8	91.0	37	203.3	121.8	97	254.7	152.7
58	49.7	29.8	18	101.2	60.7	78	152.7	91.5	38	204.1	122.4	98	255.6	153.2
59	50.6	30.3	19	102.1	61.2	79	153.5	92.0	39	205.0	122.9	99	256.5	153.7
60	51.5	30.8	20	102.9	61.7	80	154.4	92.5	40	205.9	123.4	300	257.3	154.2
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.
N.E.byE.¼E.			S.E.byE.¼E.			N.W.byW.¼W.			S W.byW.¼W.			[For 5¼ Points.		

Digitized by Google

TABLE I.

Difference of Latitude and Departure for 3 Points.

N.E.byN.			N.W.byN.			S.E.byS.			S.W.byS.					
Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	50.7	33.9	121	100.6	67.2	181	150.5	100.6	241	200.4	133.9
2	01.7	01.1	62	51.6	34.4	22	101.4	67.8	82	151.3	101.1	42	201.2	134.4
3	02.5	01.7	63	52.4	35.0	23	102.3	68.3	83	152.2	101.7	43	202.0	135.0
4	03.3	02.2	64	53.2	35.6	24	103.1	68.9	84	153.0	102.2	44	202.9	135.6
5	04.2	02.8	65	54.0	36.1	25	103.9	69.4	85	153.8	102.8	45	203.7	136.1
6	05.0	03.3	66	54.9	36.7	26	104.8	70.0	86	154.7	103.3	46	204.5	136.7
7	05.8	03.9	67	55.7	37.2	27	105.6	70.6	87	155.5	103.9	47	205.4	137.2
8	06.7	04.4	68	56.5	37.8	28	106.4	71.1	88	156.3	104.4	48	206.2	137.8
9	07.5	05.0	69	57.4	38.3	29	107.3	71.7	89	157.1	105.0	49	207.0	138.3
10	08.3	05.6	70	58.2	38.9	30	108.1	72.2	90	158.0	105.6	50	207.9	138.9
11	09.1	06.1	71	59.0	39.4	131	108.9	72.8	191	158.8	106.1	251	208.7	139.4
12	10.0	06.7	72	59.9	40.0	32	109.8	73.3	92	159.6	106.7	52	209.5	140.0
13	10.8	07.2	73	60.7	40.6	33	110.6	73.9	93	160.5	107.2	53	210.4	140.6
14	11.6	07.8	74	61.5	41.1	34	111.4	74.4	94	161.3	107.8	54	211.2	141.1
15	12.5	08.3	75	62.4	41.7	35	112.2	75.0	95	162.1	108.3	55	212.0	141.7
16	13.3	08.9	76	63.2	42.2	36	113.1	75.6	96	163.0	108.9	56	212.9	142.2
17	14.1	09.4	77	64.0	42.8	37	113.9	76.1	97	163.8	109.4	57	213.7	142.8
18	15.0	10.0	78	64.9	43.3	38	114.7	76.7	98	164.6	110.0	58	214.5	143.3
19	15.8	10.6	79	65.7	43.9	39	115.6	77.2	99	165.5	110.6	59	215.4	143.9
20	16.6	11.1	80	66.5	44.4	40	116.4	77.8	200	166.3	111.1	60	216.2	144.4
21	17.5	11.7	81	67.3	45.0	141	117.2	78.3	201	167.1	111.7	261	217.0	145.0
22	18.3	12.2	82	68.2	45.6	42	118.1	78.9	02	168.0	112.2	62	217.8	145.6
23	19.1	12.8	83	69.0	46.1	43	118.9	79.4	03	168.8	112.8	63	218.7	146.1
24	20.0	13.3	84	69.8	46.7	44	119.7	80.0	04	169.6	113.3	64	219.5	146.7
25	20.8	13.9	85	70.7	47.2	45	120.6	80.6	05	170.5	113.9	65	220.3	147.2
26	21.6	14.4	86	71.5	47.8	46	121.4	81.1	06	171.3	114.4	66	221.2	147.8
27	22.4	15.0	87	72.3	48.3	47	122.2	81.7	07	172.1	115.0	67	222.0	148.3
28	23.3	15.6	88	73.2	48.9	48	123.1	82.2	08	172.9	115.6	68	222.8	148.9
29	24.1	16.1	89	74.0	49.4	49	123.9	82.8	09	173.8	116.1	69	223.7	149.4
30	24.9	16.7	90	74.8	50.0	50	124.7	83.3	10	174.6	116.7	70	224.5	150.0
31	25.8	17.2	91	75.7	50.6	151	125.6	83.9	211	175.4	117.2	271	225.3	150.6
32	26.6	17.8	92	76.5	51.1	52	126.4	84.4	12	176.3	117.8	72	226.2	151.1
33	27.4	18.3	93	77.3	51.7	53	127.2	85.0	13	177.1	118.3	73	227.0	151.7
34	28.3	18.9	94	78.2	52.2	54	128.0	85.6	14	177.9	118.9	74	227.8	152.2
35	29.1	19.4	95	79.0	52.8	55	128.9	86.1	15	178.8	119.4	75	228.7	152.8
36	29.9	20.0	96	79.8	53.3	56	129.7	86.7	16	179.6	120.0	76	229.5	153.3
37	30.8	20.6	97	80.7	53.9	57	130.5	87.2	17	180.4	120.6	77	230.3	153.9
38	31.6	21.1	98	81.5	54.4	58	131.4	87.8	18	181.3	121.1	78	231.1	154.4
39	32.4	21.7	99	82.3	55.0	59	132.2	88.3	19	182.1	121.7	79	232.0	155.0
40	33.3	22.2	100	83.1	55.6	60	133.0	88.9	20	182.9	122.2	80	232.8	155.6
41	34.1	22.8	101	84.0	56.1	161	133.9	89.4	221	183.8	122.8	281	233.6	156.1
42	34.9	23.3	02	84.8	56.7	62	134.7	90.0	22	184.6	123.3	82	234.5	156.7
43	35.8	23.9	03	85.6	57.2	63	135.5	90.6	23	185.4	123.9	83	235.3	157.2
44	36.6	24.4	04	86.5	57.8	64	136.4	91.1	24	186.2	124.4	84	236.1	157.8
45	37.4	25.0	05	87.3	58.3	65	137.2	91.7	25	187.1	125.0	85	237.0	158.3
46	38.2	25.6	06	88.1	58.9	66	138.0	92.2	26	187.9	125.6	86	237.8	158.9
47	39.1	26.1	07	89.0	59.4	67	138.9	92.8	27	188.7	126.1	87	238.6	159.4
48	39.9	26.7	08	89.8	60.0	68	139.7	93.3	28	189.6	126.7	88	239.5	160.0
49	40.7	27.2	09	90.6	60.6	69	140.5	93.9	29	190.4	127.2	89	240.3	160.6
50	41.6	27.8	10	91.5	61.1	70	141.3	94.4	30	191.2	127.8	90	241.1	161.1
51	42.4	28.3	111	92.3	61.7	171	142.2	95.0	231	192.1	128.3	291	242.0	161.7
52	43.2	28.9	12	93.1	62.2	72	143.0	95.6	32	192.9	128.9	92	242.8	162.2
53	44.1	29.4	13	94.0	62.8	73	143.8	96.1	33	193.7	129.4	93	243.6	162.8
54	44.9	30.0	14	94.8	63.3	74	144.7	96.7	34	194.6	130.0	94	244.5	163.3
55	45.7	30.6	15	95.6	63.9	75	145.5	97.2	35	195.4	130.6	95	245.3	163.9
56	46.6	31.1	16	96.5	64.4	76	146.3	97.8	36	196.2	131.1	96	246.1	164.4
57	47.4	31.7	17	97.3	65.0	77	147.2	98.3	37	197.1	131.7	97	246.9	165.0
58	48.2	32.2	18	98.1	65.6	78	148.0	98.9	38	197.9	132.2	98	247.8	165.6
59	49.1	32.8	19	98.9	66.1	79	148.8	99.4	39	198.7	132.8	99	248.6	166.1
60	49.9	33.3	20	99.8	66.7	80	149.7	100.0	40	199.6	133.3	300	249.4	166.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.
N.E.byE.			S.E.byE.			N.W byW.			S.W.byW.			[For 5 Points.		

Digitized by Google

TABLE I.

Difference of Latitude and Departure for 3¾ Points.

	N.E.¾N.			N.W.¾N.			S.E.¾S.			S.W.¾S.				
Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	49.0	36.3	121	97.2	72.1	181	145.4	107.8	241	193.6	143.6
2	01.6	01.2	62	49.8	36.9	22	98.0	72.7	82	146.2	108.4	42	194.4	144.2
3	02.4	01.8	63	50.6	37.5	23	98.8	73.3	83	147.0	109.0	43	195.2	144.8
4	03.2	02.4	64	51.4	38.1	24	99.6	73.9	84	147.8	109.6	44	196.0	145.4
5	04.0	03.0	65	52.2	38.7	25	100.4	74.5	85	148.6	110.2	45	196.8	145.9
6	04.8	03.6	66	53.0	39.3	26	101.2	75.1	86	149.4	110.8	46	197.6	146.5
7	05.6	04.2	67	53.8	39.9	27	102.0	75.7	87	150.2	111.4	47	198.4	147.1
8	06.4	04.8	68	54.6	40.5	28	102.8	76.2	88	151.0	112.0	48	199.2	147.7
9	07.2	05.4	69	55.4	41.1	29	103.6	76.8	89	151.8	112.6	49	200.0	148.3
10	08.0	06.0	70	56.2	41.7	30	104.4	77.4	90	152.6	113.2	50	200.8	148.9
11	08.8	06.6	71	57.0	42.3	131	105.2	78.0	191	153.4	113.8	251	201.6	149.5
12	09.6	07.1	72	57.8	42.9	32	106.0	78.6	92	154.2	114.4	52	202.4	150.1
13	10.4	07.7	73	58.6	43.5	33	106.8	79.2	93	155.0	115.0	53	203.2	150.7
14	11.2	08.3	74	59.4	44.1	34	107.6	79.8	94	155.8	115.6	54	204.0	151.3
15	12.0	08.9	75	60.2	44.7	35	108.4	80.4	95	156.6	116.2	55	204.8	151.9
16	12.9	09.5	76	61.0	45.3	36	109.2	81.0	96	157.4	116.8	56	205.6	152.5
17	13.7	10.1	77	61.8	45.9	37	110.0	81.6	97	158.2	117.4	57	206.4	153.1
18	14.5	10.7	78	62.7	46.5	38	110.8	82.2	98	159.0	117.9	58	207.2	153.7
19	15.3	11.3	79	63.5	47.1	39	111.6	82.8	99	159.8	118.5	59	208.0	154.3
20	16.1	11.9	80	64.3	47.7	40	112.4	83.4	200	160.6	119.1	60	208.8	154.9
21	16.9	12.5	81	65.1	48.3	141	113.3	84.0	201	161.4	119.7	261	209.6	155.5
22	17.7	13.1	82	65.9	48.8	42	114.1	84.6	02	162.2	120.3	62	210.4	156.1
23	18.5	13.7	83	66.7	49.4	43	114.9	85.2	03	163.1	120.9	63	211.2	156.7
24	19.3	14.3	84	67.5	50.0	44	115.7	85.8	04	163.9	121.5	64	212.0	157.3
25	20.1	14.9	85	68.3	50.6	45	116.5	86.4	05	164.7	122.1	65	212.8	157.9
26	20.9	15.5	86	69.1	51.2	46	117.3	87.0	06	165.5	122.7	66	213.7	158.5
27	21.7	16.1	87	69.9	51.8	47	118.1	87.6	07	166.3	123.3	67	214.5	159.1
28	22.5	16.7	88	70.7	52.4	48	118.9	88.2	08	167.1	123.9	68	215.3	159.6
29	23.3	17.3	89	71.5	53.0	49	119.7	88.8	09	167.9	124.5	69	216.1	160.2
30	24.1	17.9	90	72.3	53.6	50	120.5	89.4	10	168.7	125.1	70	216.9	160.8
31	24.9	18.5	91	73.1	54.2	151	121.3	90.0	211	169.5	125.7	271	217.7	161.4
32	25.7	19.1	92	73.9	54.8	52	122.1	90.5	12	170.3	126.3	72	218.5	162.0
33	26.5	19.7	93	74.7	55.4	53	122.9	91.1	13	171.1	126.9	73	219.3	162.6
34	27.3	20.3	94	75.5	56.0	54	123.7	91.7	14	171.9	127.5	74	220.1	163.2
35	28.1	20.8	95	76.3	56.6	55	124.5	92.3	15	172.7	128.1	75	220.9	163.8
36	28.9	21.4	96	77.1	57.2	56	125.3	92.9	16	173.5	128.7	76	221.7	164.4
37	29.7	22.0	97	77.9	57.8	57	126.1	93.5	17	174.3	129.3	77	222.5	165.0
38	30.5	22.6	98	78.7	58.4	58	126.9	94.1	18	175.1	129.9	78	223.3	165.6
39	31.3	23.2	99	79.5	59.0	59	127.7	94.7	19	175.9	130.5	79	224.1	166.2
40	32.1	23.8	100	80.3	59.6	60	128.5	95.3	20	176.7	131.1	80	224.9	166.8
41	32.9	24.4	101	81.1	60.2	161	129.3	95.9	221	177.5	131.6	281	225.7	167.4
42	33.7	25.0	02	81.9	60.8	62	130.1	96.5	22	178.3	132.2	82	226.5	168.0
43	34.5	25.6	03	82.7	61.4	63	130.9	97.1	23	179.1	132.8	83	227.3	168.6
44	35.3	26.2	04	83.5	62.0	64	131.7	97.7	24	179.9	133.4	84	228.1	169.2
45	36.1	26.8	05	84.3	62.5	65	132.5	98.3	25	180.7	134.0	85	228.9	169.8
46	36.9	27.4	06	85.1	63.1	66	133.3	98.9	26	181.5	134.6	86	229.7	170.4
47	37.8	28.0	07	85.9	63.7	67	134.1	99.5	27	182.3	135.2	87	230.5	171.0
48	38.6	28.6	08	86.7	64.3	68	134.9	100.1	28	183.1	135.8	88	231.3	171.6
49	39.4	29.2	09	87.5	64.9	69	135.7	100.7	29	183.9	136.4	89	232.1	172.2
50	40.2	29.8	10	88.4	65.5	70	136.5	101.3	30	184.7	137.0	90	232.9	172.8
51	41.0	30.4	111	89.2	66.1	171	137.3	101.9	231	185.5	137.6	291	233.7	173.3
52	41.8	31.0	12	90.0	66.7	72	138.2	102.5	32	186.3	138.2	92	234.5	173.9
53	42.6	31.6	13	90.8	67.3	73	139.0	103.1	33	187.1	138.8	93	235.3	174.5
54	43.4	32.2	14	91.6	67.9	74	139.8	103.7	34	188.0	139.4	94	236.1	175.1
55	44.2	32.8	15	92.4	68.5	75	140.6	104.2	35	188.8	140.0	95	236.9	175.7
56	45.0	33.4	16	93.2	69.1	76	141.4	104.8	36	189.6	140.6	96	237.7	176.3
57	45.8	34.0	17	94.0	69.7	77	142.2	105.4	37	190.4	141.2	97	238.6	176.9
58	46.6	34.6	18	94.8	70.3	78	143.0	106.0	38	191.2	141.8	98	239.4	177.5
59	47.4	35.1	19	95.6	70.9	79	143.8	106.6	39	192.0	142.4	99	240.2	178.1
60	48.2	35.7	20	96.4	71.5	80	144.6	107.2	40	192.8	143.0	300	241.0	178.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.
	N.E.¾E.			S.E.¾E.			N.W.¾W.			S.W.¾W.			[For 4¼ Points.	

Digitized by Google

TABLE I.

Difference of Latitude and Departure for 3½ Points.

N.E ½N.			N.W.½N.			S.E.½S.			S.W.½S.					
Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	47.2	38.7	121	93.5	76.8	181	139.9	114.8	241	186.3	152.9
2	01.5	01.3	62	47.9	39.3	22	94.3	77.4	82	140.7	115.5	42	187.1	153.5
3	02.3	01.9	63	48.7	40.0	23	95.1	78.0	83	141.5	116.1	43	187.8	154.2
4	03.1	02.5	64	49.5	40.6	24	95.9	78.7	84	142.2	116.7	44	188.6	154.8
5	03.9	03.2	65	50.2	41.2	25	96.6	79.3	85	143.0	117.4	45	189.4	155.4
6	04.6	03.8	66	51.0	41.9	26	97.4	79.9	86	143.8	118.0	46	190.2	156.1
7	05.4	04.4	67	51.8	42.5	27	98.2	80.6	87	144.6	118.6	47	190.9	156.7
8	06.2	05.1	68	52.6	43.1	28	98.9	81.2	88	145.3	119.3	48	191.7	157.3
9	07.0	05.7	69	53.3	43.8	29	99.7	81.8	89	146.1	119.9	49	192.5	158.0
10	07.7	06.3	70	54.1	44.4	30	100.5	82.5	90	146.9	120.5	50	193.3	158.6
11	08.5	07.0	71	54.9	45.0	131	101.3	83.1	191	147.6	121.2	251	194.0	159.2
12	09.3	07.6	72	55.7	45.7	32	102.0	83.7	92	148.4	121.8	52	194.8	159.9
13	10.0	08.2	73	56.4	46.3	33	102.8	84.4	93	149.2	122.4	53	195.6	160.5
14	10.8	08.9	74	57.2	46.9	34	103.6	85.0	94	150.0	123.1	54	196.3	161.1
15	11.6	09.5	75	58.0	47.6	35	104.4	85.6	95	150.7	123.7	55	197.1	161.8
16	12.4	10.2	76	58.7	48.2	36	105.1	86.3	96	151.5	124.3	56	197.9	162.4
17	13.1	10.8	77	59.5	48.8	37	105.9	86.9	97	152.3	125.0	57	198.7	163.0
18	13.9	11.4	78	60.3	49.5	38	106.7	87.5	98	153.1	125.6	58	199.4	163.7
19	14.7	12.1	79	61.1	50.1	39	107.4	88.2	99	153.8	126.2	59	200.2	164.3
20	15.5	12.7	80	61.8	50.8	40	108.2	88.8	200	154.6	126.9	60	201.0	164.9
21	16.2	13.3	81	62.6	51.4	141	109.0	89.4	201	155.4	127.5	261	201.8	165.6
22	17.0	14.0	82	63.4	52.0	42	109.8	90.1	02	156.1	128.1	62	202.5	166.2
23	17.8	14.6	83	64.2	52.7	43	110.5	90.7	03	156.9	128.8	63	203.3	166.8
24	18.6	15.2	84	64.9	53.3	44	111.3	91.4	04	157.7	129.4	64	204.1	167.5
25	19.3	15.9	85	65.7	53.9	45	112.1	92.0	05	158.5	130.1	65	204.8	168.1
26	20.1	16.5	86	66.5	54.6	46	112.9	92.6	06	159.2	130.7	66	205.6	168.7
27	20.9	17.1	87	67.3	55.2	47	113.6	93.3	07	160.0	131.3	67	206.4	169.4
28	21.6	17.8	88	68.0	55.8	48	114.4	93.9	08	160.8	132.0	68	207.2	170.0
29	22.4	18.4	89	68.8	56.5	49	115.2	94.5	09	161.6	132.6	69	207.9	170.7
30	23.2	19.0	90	69.6	57.1	50	116.0	95.2	10	162.3	133.2	70	208.7	171.3
31	24.0	19.7	91	70.3	57.7	151	116.7	95.8	211	163.1	133.9	271	209.5	171.9
32	24.7	20.3	92	71.1	58.4	52	117.5	96.4	12	163.9	134.5	72	210.3	172.6
33	25.5	20.9	93	71.9	59.0	53	118.3	97.1	13	164.7	135.1	73	211.0	173.2
34	26.3	21.6	94	72.7	59.6	54	119.0	97.7	14	165.4	135.8	74	211.8	173.8
35	27.1	22.2	95	73.4	60.3	55	119.8	98.3	15	166.2	136.4	75	212.6	174.5
36	27.8	22.8	96	74.2	60.9	56	120.6	99.0	16	167.0	137.0	76	213.4	175.1
37	28.6	23.5	97	75.0	61.5	57	121.4	99.6	17	167.7	137.7	77	214.1	175.7
38	29.4	24.1	98	75.8	62.2	58	122.1	100.2	18	168.5	138.3	78	214.9	176.4
39	30.1	24.7	99	76.5	62.8	59	122.9	100.9	19	169.3	138.9	79	215.7	177.0
40	30.9	25.4	100	77.3	63.4	60	123.7	101.5	20	170.1	139.6	80	216.4	177.6
41	31.7	26.0	101	78.1	64.1	161	124.5	102.1	221	170.8	140.2	281	217.2	178.3
42	32.5	26.6	02	78.8	64.7	62	125.2	102.8	22	171.6	140.8	82	218.0	178.9
43	33.2	27.3	03	79.6	65.3	63	126.0	103.4	23	172.4	141.5	83	218.8	179.5
44	34.0	27.9	04	80.4	66.0	64	126.8	104.0	24	173.2	142.1	84	219.5	180.2
45	34.8	28.5	05	81.2	66.6	65	127.5	104.7	25	173.9	142.7	85	220.3	180.8
46	35.6	29.2	06	81.9	67.2	66	128.3	105.3	26	174.7	143.4	86	221.1	181.4
47	36.3	29.8	07	82.7	67.9	67	129.1	105.9	27	175.5	144.0	87	221.9	182.1
48	37.1	30.5	08	83.5	68.5	68	129.9	106.6	28	176.2	144.6	88	222.6	182.7
49	37.9	31.1	09	84.3	69.1	69	130.6	107.2	29	177.0	145.3	89	223.4	183.3
50	38.7	31.7	10	85.0	69.8	70	131.4	107.8	30	177.8	145.9	90	224.2	184.0
51	39.4	32.4	111	85.8	70.4	171	132.2	108.5	231	178.6	146.5	291	224.9	184.6
52	40.2	33.0	12	86.6	71.1	72	133.0	109.1	32	179.3	147.2	92	225.7	185.2
53	41.0	33.6	13	87.4	71.7	73	133.7	109.8	33	180.1	147.8	93	226.5	185.9
54	41.7	34.3	14	88.1	72.3	74	134.5	110.4	34	180.9	148.4	94	227.3	186.5
55	42.5	34.9	15	88.9	73.0	75	135.3	111.0	35	181.7	149.1	95	228.0	187.1
56	43.3	35.5	16	89.7	73.6	76	136.0	111.7	36	182.4	149.7	96	228.8	187.8
57	44.1	36.2	17	90.4	74.2	77	136.8	112.3	37	183.2	150.4	97	229.6	188.4
58	44.8	36.8	18	91.2	74.9	78	137.6	112.9	38	184.0	151.0	98	230.4	189.0
59	45.6	37.4	19	92.0	75.5	79	138.4	113.6	39	184.7	151.6	99	231.1	189.7
60	46.4	38.1	20	92.8	76.1	80	139.1	114.2	40	185.5	152.3	300	231.9	190.3
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.
N.E.½E.			S.E.½E.			N.W.½W.			S.W.½W.			[For 4½ Points.		

Digitized by Google

TABLE I.

Difference of Latitude and Departure for 3¾ Points.

N.E.¼N.						N.W.¼N.			S.E.¼S.			S.W.¼S.		
Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.7	00.7	61	45.2	41.0	121	89.7	81.3	181	134.1	121.6	241	178.6	161.8
2	01.5	01.3	62	45.9	41.6	22	90.4	81.9	82	134.9	122.2	42	179.3	162.5
3	02.2	02.0	63	46.7	42.3	23	91.1	82.6	83	135.6	122.9	43	180.1	163.2
4	03.0	02.7	64	47.4	43.0	24	91.9	83.3	84	136.3	123.6	44	180.8	163.9
5	03.7	03.4	65	48.2	43.7	25	92.6	83.9	85	137.1	124.2	45	181.5	164.5
6	04.4	04.0	66	48.9	44.3	26	93.4	84.6	86	137.8	124.9	46	182.3	165.2
7	05.2	04.7	67	49.6	45.0	27	[illegible]	85.3	87	138.6	125.6	47	183.0	165.9
8	05.9	05.4	68	50.4	45.7	28	94.8	86.0	88	139.3	126.3	48	183.8	166.5
9	06.7	06.0	69	51.1	46.3	29	95.6	86.6	89	140.0	126.9	49	184.5	167.2
10	07.4	06.7	70	51.9	47.0	30	96.3	87.3	90	140.8	127.6	50	185.2	167.9
11	08.2	07.4	71	52.6	47.7	131	97.1	88.0	191	141.5	128.3	251	186.0	168.6
12	08.9	08.1	72	53.3	48.4	32	97.8	88.6	92	142.3	128.9	52	186.7	169.2
13	09.6	08.7	73	54.1	49.0	33	98.5	89.3	93	143.0	129.6	53	187.5	169.9
14	10.4	09.4	74	54.8	49.7	34	99.3	90.0	94	143.7	130.3	54	188.2	170.6
15	11.1	10.1	75	55.6	50.4	35	100.0	90.7	95	144.5	131.0	55	188.9	171.2
16	11.9	10.7	76	56.3	51.0	36	100.8	91.3	96	145.2	131.6	56	189.7	171.9
17	12.6	11.4	77	57.1	51.7	37	101.5	92.0	97	146.0	132.3	57	190.4	172.6
18	13.3	12.1	78	57.8	52.4	38	102.3	92.7	98	146.7	133.0	58	191.2	173.3
19	14.1	12.8	79	58.5	53.1	39	103.0	93.3	99	147.4	133.6	59	191.9	173.9
20	14.8	13.4	80	59.3	53.7	40	103.7	94.0	200	148.2	134.3	60	192.6	174.6
21	15.6	14.1	81	60.0	54.4	141	104.5	94.7	201	148.9	135.0	261	193.4	175.3
22	16.3	14.8	82	60.8	55.1	42	105.2	95.4	02	149.7	135.7	62	194.1	175.9
23	17.0	15.4	83	61.5	55.7	43	106.0	96.0	03	150.4	136.3	63	194.9	176.6
24	17.8	16.1	84	62.2	56.4	44	106.7	96.7	04	151.2	137.0	64	195.6	[illegible]
25	18.5	16.8	85	63.0	57.1	45	107.4	97.4	05	151.9	137.7	65	196.4	178.0
26	19.3	17.5	86	63.7	57.8	46	108.2	98.0	06	152.6	138.3	66	197.1	178.6
27	20.0	18.1	87	64.5	58.4	47	108.9	98.7	07	153.4	139.0	67	197.8	179.3
28	20.7	18.8	88	65.2	59.1	48	109.7	99.4	08	154.1	139.7	68	198.6	180.0
29	21.5	19.5	89	65.9	59.8	49	110.4	100.1	09	154.9	140.4	69	199.3	180.6
30	22.2	20.1	90	66.7	60.4	50	111.1	100.7	10	155.6	141.0	70	200.1	181.3
31	23.0	20.8	91	67.4	61.1	151	111.9	101.4	211	156.3	141.7	271	200.8	[illegible]
32	23.7	21.5	92	68.2	61.8	52	112.6	102.1	12	157.1	142.4	72	201.5	182.7
33	24.5	22.2	93	68.9	62.5	53	113.4	102.7	13	157.8	143.0	73	202.3	183.3
34	25.2	22.8	94	69.6	63.1	54	114.1	103.4	14	158.6	143.7	74	203.0	184.0
35	25.9	23.5	95	70.4	63.8	55	114.8	104.1	15	159.3	144.4	75	203.8	184.7
36	26.7	24.2	96	71.1	64.5	56	115.6	104.8	16	160.0	145.1	76	204.5	185.4
37	27.4	24.8	97	71.9	65.1	57	116.3	105.4	17	160.8	145.7	77	205.2	186.0
38	28.2	25.5	98	72.6	65.8	58	117.1	106.1	18	161.5	146.4	78	206.0	186.7
39	28.9	26.2	99	73.4	66.5	59	117.8	106.8	19	162.3	147.1	79	206.7	187.4
40	29.6	26.9	100	74.1	67.2	60	118.6	107.4	20	163.0	147.7	80	207.5	188.0
41	30.4	27.5	101	74.8	67.8	161	119.3	108.1	221	163.8	148.4	281	208.2	188.7
42	31.1	28.2	02	75.6	68.5	62	120.0	108.8	22	164.5	149.1	82	208.9	189.4
43	31.9	28.9	03	76.3	69.2	63	120.8	109.5	23	165.2	149.8	83	209.7	190.1
44	32.6	29.5	04	77.1	69.8	64	121.5	110.1	24	166.0	150.4	84	210.4	190.7
45	33.3	30.2	05	77.8	70.5	65	122.3	110.8	25	166.7	151.1	85	211.2	191.4
46	34.1	30.9	06	78.5	71.2	66	123.0	111.5	26	167.5	151.8	86	211.9	192.1
47	34.8	31.6	07	79.3	71.9	67	123.7	112.2	27	168.2	152.4	87	212.7	192.7
48	35.6	32.2	08	80.0	72.5	68	124.5	112.8	28	168.9	153.1	88	213.4	193.4
49	36.3	32.9	09	80.8	73.2	69	125.2	113.5	29	169.7	153.8	89	214.1	194.1
50	37.0	33.6	10	81.5	73.9	70	126.0	114.2	30	170.4	154.5	90	214.9	194.8
51	37.8	34.2	111	82.2	74.5	171	126.7	114.8	231	171.2	155.1	291	215.6	195.4
52	38.5	34.9	12	83.0	75.2	72	127.4	115.5	32	171.9	155.8	92	216.4	196.1
53	39.3	35.6	13	83.7	75.9	73	128.2	116.2	33	172.6	156.5	93	217.1	196.8
54	40.0	36.3	14	84.5	76.6	74	128.9	116.9	34	173.4	157.1	94	217.8	197.4
55	40.8	36.9	15	85.2	77.2	75	129.7	117.5	35	174.1	157.8	95	218.6	198.1
56	41.5	37.6	16	86.0	77.9	76	130.4	118.2	36	174.9	158.5	96	219.3	198.8
57	42.2	38.3	17	86.7	78.6	77	131.1	118.9	37	175.6	159.2	97	220.1	199.5
58	43.0	39.0	18	87.4	79.2	78	131.9	119.5	38	176.3	159.8	98	220.8	200.1
59	43.7	39.6	19	88.2	79.9	79	132.6	120.2	39	177.1	160.5	99	221.5	200.8
60	44.5	40.3	20	88.9	80.6	80	133.4	120.9	40	177.8	161.2	300	222.3	201.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.
N.E.¼E.			S.E.¼E.			N.W.¼W.			S.W.¼W.			[For 4¼ Points.		

Digitized by Google

TABLE I.

Difference of Latitude and Departure for 4 Points.

N.E. N.W. S.E. S.W.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.7	00.7	61	43.1	43.1	121	85.6	85.6	181	128.0	128.0	241	170.4	170.4
2	01.4	01.4	62	43.8	43.8	22	86.3	86.3	82	128.7	128.7	42	171.1	171.1
3	02.1	02.1	63	44.5	44.5	23	87.0	87.0	83	129.4	129.4	43	171.8	171.8
4	02.8	02.8	64	45.3	45.3	24	87.7	87.7	84	130.1	130.1	44	172.5	172.5
5	03.5	03.5	65	46.0	46.0	25	88.4	88.4	85	130.8	130.8	45	173.2	173.2
6	04.2	04.2	66	46.7	46.7	26	89.1	89.1	86	131.5	131.5	46	173.9	173.9
7	04.9	04.9	67	47.4	47.4	27	89.8	89.8	87	132.2	132.2	47	174.7	174.7
8	05.7	05.7	68	48.1	48.1	28	90.5	90.5	88	132.9	132.9	48	175.4	175.4
9	06.4	06.4	69	48.8	48.8	29	91.2	91.2	89	133.6	133.6	49	176.1	176.1
10	07.1	07.1	70	49.5	49.5	30	91.9	91.9	90	134.4	134.4	50	176.8	176.8
11	07.8	07.8	71	50.2	50.2	131	92.6	92.6	191	135.1	135.1	251	177.5	177.5
12	08.5	08.5	72	50.9	50.9	32	93.3	93.3	92	135.8	135.8	52	178.2	178.2
13	09.2	09.2	73	51.6	51.6	33	94.0	94.0	93	136.5	136.5	53	178.9	178.9
14	09.9	09.9	74	52.3	52.3	34	94.8	94.8	94	137.2	137.2	54	179.6	179.6
15	10.6	10.6	75	53.0	53.0	35	95.5	95.5	95	137.9	137.9	55	180.3	180.3
16	11.3	11.3	76	53.7	53.7	36	96.2	96.2	96	138.6	138.6	56	181.0	181.0
17	12.0	12.0	77	54.4	54.4	37	96.9	96.9	97	139.3	139.3	57	181.7	181.7
18	12.7	12.7	78	55.2	55.2	38	97.6	97.6	98	140.0	140.0	58	182.4	182.4
19	13.4	13.4	79	55.9	55.9	39	98.3	98.3	99	140.7	140.7	59	183.1	183.1
20	14.1	14.1	80	56.6	56.6	40	99.0	99.0	200	141.4	141.4	60	183.8	183.8
21	14.8	14.8	81	57.3	57.3	141	99.7	99.7	201	142.1	142.1	261	184.6	184.6
22	15.6	15.6	82	58.0	58.0	42	100.4	100.4	02	142.8	142.8	62	185.3	185.3
23	16.3	16.3	83	58.7	58.7	43	101.1	101.1	03	143.5	143.5	63	186.0	186.0
24	17.0	17.0	84	59.4	59.4	44	101.8	101.8	04	144.2	144.2	64	186.7	186.7
25	17.7	17.7	85	60.1	60.1	45	102.5	102.5	05	145.0	145.0	65	187.4	187.4
26	18.4	18.4	86	60.8	60.8	46	103.2	103.2	06	145.7	145.7	66	188.1	188.1
27	19.1	19.1	87	61.5	61.5	47	103.9	103.9	07	146.4	146.4	67	188.8	188.8
28	19.8	19.8	88	62.2	62.2	48	104.7	104.7	08	147.1	147.1	68	189.5	189.5
29	20.5	20.5	89	62.9	62.9	49	105.4	105.4	09	147.8	147.8	69	190.2	190.2
30	21.2	21.2	90	63.6	63.6	50	106.1	106.1	10	148.5	148.5	70	190.9	190.9
31	21.9	21.9	91	64.3	64.3	151	106.8	106.8	211	149.2	149.2	271	191.6	191.6
32	22.6	22.6	92	65.1	65.1	52	107.5	107.5	12	149.9	149.9	72	192.3	192.3
33	23.3	23.3	93	65.8	65.8	53	108.2	108.2	13	150.6	150.6	73	193.0	193.0
34	24.0	24.0	94	66.5	66.5	54	108.9	108.9	14	151.3	151.3	74	193.7	193.7
35	24.7	24.7	95	67.2	67.2	55	109.6	109.6	15	152.0	152.0	75	194.5	194.5
36	25.5	25.5	96	67.9	67.9	56	110.3	110.3	16	152.7	152.7	76	195.2	195.2
37	26.2	26.2	97	68.6	68.6	57	111.0	111.0	17	153.4	153.4	77	195.9	195.9
38	26.9	26.9	98	69.3	69.3	58	111.7	111.7	18	154.1	154.1	78	196.6	196.6
39	27.6	27.6	99	70.0	70.0	59	112.4	112.4	19	154.9	154.9	79	197.3	197.3
40	28.3	28.3	100	70.7	70.7	60	113.1	113.1	20	155.6	155.6	80	198.0	198.0
41	29.0	29.0	101	71.4	71.4	161	113.8	113.8	221	156.3	156.3	281	198.7	198.7
42	29.7	29.7	02	72.1	72.1	62	114.6	114.6	22	157.0	157.0	82	199.4	199.4
43	30.4	30.4	03	72.8	72.8	63	115.3	115.3	23	157.7	157.7	83	200.1	200.1
44	31.1	31.1	04	73.5	73.5	64	116.0	116.0	24	158.4	158.4	84	200.8	200.8
45	31.8	31.8	05	74.2	74.2	65	116.7	116.7	25	159.1	159.1	85	201.5	201.5
46	32.5	32.5	06	75.0	75.0	66	117.4	117.4	26	159.8	159.8	86	202.2	202.2
47	33.2	33.2	07	75.7	75.7	67	118.1	118.1	27	160.5	160.5	87	202.9	202.9
48	33.9	33.9	08	76.4	76.4	68	118.8	118.8	28	161.2	161.2	88	203.6	203.6
49	34.6	34.6	09	77.1	77.1	69	119.5	119.5	29	161.9	161.9	89	204.4	204.4
50	35.4	35.4	10	77.8	77.8	70	120.2	120.2	30	162.6	162.6	90	205.1	205.1
51	36.1	36.1	111	78.5	78.5	171	120.9	120.9	231	163.3	163.3	291	205.8	205.8
52	36.8	36.8	12	79.2	79.2	72	121.6	121.6	32	164.0	164.0	92	206.5	206.5
53	37.5	37.5	13	79.9	79.9	73	122.3	122.3	33	164.8	164.8	93	207.2	207.2
54	38.2	38.2	14	80.6	80.6	74	123.0	123.0	34	165.5	165.5	94	207.9	207.9
55	38.9	38.9	15	81.3	81.3	75	123.7	123.7	35	166.2	166.2	95	208.6	208.6
56	39.6	39.6	16	82.0	82.0	76	124.5	124.5	36	166.9	166.9	96	209.3	209.3
57	40.3	40.3	17	82.7	82.7	77	125.2	125.2	37	167.6	167.6	97	210.0	210.0
58	41.0	41.0	18	83.4	83.4	78	125.9	125.9	38	168.3	168.3	98	210.7	210.7
59	41.7	41.7	19	84.1	84.1	79	126.6	126.6	39	169.0	169.0	99	211.4	211.4
60	42.4	42.4	20	84.9	84.9	80	127.3	127.3	40	169.7	169.7	300	212.1	212.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

N.E. N.W. S.E. S.W.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 1 Degree.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.0	61	61.0	01.1	121	121.0	02.1	181	181.0	03.2	241	241.0	04.2
2	02.0	00.0	62	62.0	01.1	22	122.0	02.1	82	182.0	03.2	42	242.0	04.2
3	03.0	00.1	63	63.0	01.1	23	123.0	02.1	83	183.0	03.2	43	243.0	04.2
4	04.0	00.1	64	64.0	01.1	24	124.0	02.2	84	184.0	03.2	44	244.0	04.3
5	05.0	00.1	65	65.0	01.1	25	125.0	02.2	85	185.0	03.2	45	245.0	04.3
6	06.0	00.1	66	66.0	01.2	26	126.0	02.2	86	186.0	03.2	46	246.0	04.3
7	07.0	00.1	67	67.0	01.2	27	127.0	02.2	87	187.0	03.3	47	247.0	04.3
8	08.0	00.1	68	68.0	01.2	28	128.0	02.2	88	188.0	03.3	48	248.0	04.3
9	09.0	00.2	69	69.0	01.2	29	129.0	02.3	89	189.0	03.3	49	249.0	04.3
10	10.0	00.2	70	70.0	01.2	30	130.0	02.3	90	190.0	03.3	50	250.0	04.4
11	11.0	00.2	71	71.0	01.2	131	131.0	02.3	191	191.0	03.3	251	251.0	04.4
12	12.0	00.2	72	72.0	01.3	32	132.0	02.3	92	192.0	03.4	52	252.0	04.4
13	13.0	00.2	73	73.0	01.3	33	133.0	02.3	93	193.0	03.4	53	253.0	04.4
14	14.0	00.2	74	74.0	01.3	34	134.0	02.3	94	194.0	03.4	54	254.0	04.4
15	15.0	00.3	75	75.0	01.3	35	135.0	02.4	95	195.0	03.4	55	255.0	04.5
16	16.0	00.3	76	76.0	01.3	36	136.0	02.4	96	196.0	03.4	56	256.0	04.5
17	17.0	00.3	77	77.0	01.3	37	137.0	02.4	97	197.0	03.4	57	257.0	04.5
18	18.0	00.3	78	78.0	01.4	38	138.0	02.4	98	198.0	03.5	58	258.0	04.5
19	19.0	00.3	79	79.0	01.4	39	139.0	02.4	99	199.0	03.5	59	259.0	04.5
20	20.0	00.3	80	80.0	01.4	40	140.0	02.4	200	200.0	03.5	60	260.0	04.5
21	21.0	00.4	81	81.0	01.4	141	141.0	02.5	201	201.0	03.5	261	261.0	04.6
22	22.0	00.4	82	82.0	01.4	42	142.0	02.5	02	202.0	03.5	62	262.0	04.6
23	23.0	00.4	83	83.0	01.4	43	143.0	02.5	03	203.0	03.5	63	263.0	04.6
24	24.0	00.4	84	84.0	01.5	44	144.0	02.5	04	204.0	03.6	64	264.0	04.6
25	25.0	00.4	85	85.0	01.5	45	145.0	02.5	05	205.0	03.6	65	265.0	04.6
26	26.0	00.5	86	86.0	01.5	46	146.0	02.5	06	206.0	03.6	66	266.0	04.6
27	27.0	00.5	87	87.0	01.5	47	147.0	02.6	07	207.0	03.6	67	267.0	04.7
28	28.0	00.5	88	88.0	01.5	48	148.0	02.6	08	208.0	03.6	68	268.0	04.7
29	29.0	00.5	89	89.0	01.6	49	149.0	02.6	09	209.0	03.6	69	269.0	04.7
30	30.0	00.5	90	90.0	01.6	50	150.0	02.6	10	210.0	03.7	70	270.0	04.7
31	31.0	00.5	91	91.0	01.6	151	151.0	02.6	211	211.0	03.7	271	271.0	04.7
32	32.0	00.6	92	92.0	01.6	52	152.0	02.7	12	212.0	03.7	72	272.0	04.7
33	33.0	00.6	93	93.0	01.6	53	153.0	02.7	13	213.0	03.7	73	273.0	04.8
34	34.0	00.6	94	94.0	01.6	54	154.0	02.7	14	214.0	03.7	74	274.0	04.8
35	35.0	00.6	95	95.0	01.7	55	155.0	02.7	15	215.0	03.8	75	275.0	04.8
36	36.0	00.6	96	96.0	01.7	56	156.0	02.7	16	216.0	03.8	76	276.0	04.8
37	37.0	00.6	97	97.0	01.7	57	157.0	02.7	17	217.0	03.8	77	277.0	04.8
38	38.0	00.7	98	98.0	01.7	58	158.0	02.8	18	218.0	03.8	78	278.0	04.9
39	39.0	00.7	99	99.0	01.7	59	159.0	02.8	19	219.0	03.8	79	279.0	04.9
40	40.0	00.7	100	100.0	01.7	60	160.0	02.8	20	220.0	03.8	80	280.0	04.9
41	41.0	00.7	101	101.0	01.8	161	161.0	02.8	221	221.0	03.9	281	281.0	04.9
42	42.0	00.7	02	102.0	01.8	62	162.0	02.8	22	222.0	03.9	82	282.0	04.9
43	43.0	00.8	03	103.0	01.8	63	163.0	02.8	23	223.0	03.9	83	283.0	04.9
44	44.0	00.8	04	104.0	01.8	64	164.0	02.9	24	224.0	03.9	84	284.0	05.0
45	45.0	00.8	05	105.0	01.8	65	165.0	02.9	25	225.0	03.9	85	285.0	05.0
46	46.0	00.8	06	106.0	01.8	66	166.0	02.9	26	226.0	03.9	86	286.0	05.0
47	47.0	00.8	07	107.0	01.9	67	167.0	02.9	27	227.0	04.0	87	287.0	05.0
48	48.0	00.8	08	108.0	01.9	68	168.0	02.9	28	228.0	04.0	88	288.0	05.0
49	49.0	00.9	09	109.0	01.9	69	169.0	02.9	29	229.0	04.0	89	289.0	05.0
50	50.0	00.9	10	110.0	01.9	70	170.0	03.0	30	230.0	04.0	90	290.0	05.1
51	51.0	00.9	111	111.0	01.9	171	171.0	03.0	231	231.0	04.0	291	291.0	05.1
52	52.0	00.9	12	112.0	02.0	72	172.0	03.0	32	232.0	04.0	92	292.0	05.1
53	53.0	00.9	13	113.0	02.0	73	173.0	03.0	33	233.0	04.1	93	293.0	05.1
54	54.0	00.9	14	114.0	02.0	74	174.0	03.0	34	234.0	04.1	94	294.0	05.1
55	55.0	01.0	15	115.0	02.0	75	175.0	03.1	35	235.0	04.1	95	295.0	05.1
56	56.0	01.0	16	116.0	02.0	76	176.0	03.1	36	236.0	04.1	96	296.0	05.2
57	57.0	01.0	17	117.0	02.0	77	177.0	03.1	37	237.0	04.1	97	297.0	05.2
58	58.0	01.0	18	118.0	02.1	78	178.0	03.1	38	238.0	04.2	98	298.0	05.2
59	59.0	01.0	19	119.0	02.1	79	179.0	03.1	39	239.0	04.2	99	299.0	05.2
60	60.0	01.0	20	120.0	02.1	80	180.0	03.1	40	240.0	04.2	300	300.0	05.2
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 2 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.0	61	61.0	02.1	121	120.9	04.2	181	180.9	06.3	241	240.9	08.4
2	02.0	00.1	62	62.0	02.2	22	121.9	04.3	82	181.9	06.4	42	241.9	08.4
3	03.0	00.1	63	63.0	02.2	23	122.9	04.3	83	182.9	06.4	43	242.9	08.5
4	04.0	00.1	64	64.0	02.2	24	123.9	04.3	84	183.9	06.4	44	243.9	08.5
5	05.0	00.2	65	65.0	02.3	25	124.9	04.4	85	184.9	06.5	45	244.9	08.6
6	06.0	00.2	66	66.0	02.3	26	125.9	04.4	86	185.9	06.5	46	245.9	08.6
7	07.0	00.2	67	67.0	02.3	27	126.9	04.4	87	186.9	06.5	47	246.8	08.6
8	08.0	00.3	68	68.0	02.4	28	127.9	04.5	88	187.9	06.6	48	247.8	08.7
9	09.0	00.3	69	69.0	02.4	29	128.9	04.5	89	188.9	06.6	49	248.8	08.7
10	10.0	00.3	70	70.0	02.4	30	129.9	04.5	90	189.9	06.6	50	249.8	08.7
11	11.0	00.4	71	71.0	02.5	131	130.9	04.6	191	190.9	06.7	251	250.8	08.8
12	12.0	00.4	72	72.0	02.5	32	131.9	04.6	92	191.9	06.7	52	251.8	08.8
13	13.0	00.5	73	73.0	02.5	33	132.9	04.6	93	192.9	06.7	53	252.8	08.8
14	14.0	00.5	74	74.0	02.6	34	133.9	04.7	94	193.9	06.8	54	253.8	08.9
15	15.0	00.5	75	75.0	02.6	35	134.9	04.7	95	194.9	06.8	55	254.8	08.9
16	16.0	00.6	76	76.0	02.7	36	135.9	04.7	96	195.9	06.8	56	255.8	08.9
17	17.0	00.6	77	77.0	02.7	37	136.9	04.8	97	196.9	06.9	57	256.8	09.0
18	18.0	00.6	78	78.0	02.7	38	137.9	04.8	98	197.9	06.9	58	257.8	09.0
19	19.0	00.7	79	79.0	02.8	39	138.9	04.9	99	198.9	06.9	59	258.8	09.0
20	20.0	00.7	80	80.0	02.8	40	139.9	04.9	200	199.9	07.0	60	259.8	09.1
21	21.0	00.7	81	81.0	02.8	141	140.9	04.9	201	200.9	07.0	261	260.8	09.1
22	22.0	00.8	82	82.0	02.9	42	141.9	05.0	02	201.9	07.0	62	261.8	09.1
23	23.0	00.8	83	82.9	02.9	43	142.9	05.0	03	202.9	07.1	63	262.8	09.2
24	24.0	00.8	84	83.9	02.9	44	143.9	05.0	04	203.9	07.1	64	263.8	09.2
25	25.0	00.9	85	84.9	03.0	45	144.9	05.1	05	204.9	07.2	65	264.8	09.2
26	26.0	00.9	86	85.9	03.0	46	145.9	05.1	06	205.9	07.2	66	265.8	09.3
27	27.0	00.9	87	86.9	03.0	47	146.9	05.1	07	206.9	07.2	67	266.8	09.3
28	28.0	01.0	88	87.9	03.1	48	147.9	05.2	08	207.9	07.3	68	267.8	09.4
29	29.0	01.0	89	88.9	03.1	49	148.9	05.2	09	208.9	07.3	69	268.8	09.4
30	30.0	01.0	90	89.9	03.1	50	149.9	05.2	10	209.9	07.3	70	269.8	09.4
31	31.0	01.1	91	90.9	03.2	151	150.9	05.3	211	210.9	07.4	271	270.8	09.5
32	32.0	01.1	92	91.9	03.2	52	151.9	05.3	12	211.9	07.4	72	271.8	09.5
33	33.0	01.2	93	92.9	03.2	53	152.9	05.3	13	212.9	07.4	73	272.8	09.5
34	34.0	01.2	94	93.9	03.3	54	153.9	05.4	14	213.9	07.5	74	273.8	09.6
35	35.0	01.2	95	94.9	03.3	55	154.9	05.4	15	214.9	07.5	75	274.8	09.6
36	36.0	01.3	96	95.9	03.4	56	155.9	05.4	16	215.9	07.5	76	275.8	09.6
37	37.0	01.3	97	96.9	03.4	57	156.9	05.5	17	216.9	07.6	77	276.8	09.7
38	38.0	01.3	98	97.9	03.4	58	157.9	05.5	18	217.9	07.6	78	277.8	09.7
39	39.0	01.4	99	98.9	03.5	59	158.9	05.5	19	218.9	07.6	79	278.8	09.7
40	40.0	01.4	100	99.9	03.5	60	159.9	05.6	20	219.9	07.7	80	279.8	09.8
41	41.0	01.4	101	100.9	03.5	161	160.9	05.6	221	220.9	07.7	281	280.8	09.8
42	42.0	01.5	02	101.9	03.6	62	161.9	05.7	22	221.9	07.7	82	281.8	09.8
43	43.0	01.5	03	102.9	03.6	63	162.9	05.7	23	222.9	07.8	83	282.8	09.9
44	44.0	01.5	04	103.9	03.6	64	163.9	05.7	24	223.9	07.8	84	283.8	09.9
45	45.0	01.6	05	104.9	03.7	65	164.9	05.8	25	224.9	07.9	85	284.8	09.9
46	46.0	01.6	06	105.9	03.7	66	165.9	05.8	26	225.9	07.9	86	285.8	10.0
47	47.0	01.6	07	106.9	03.7	67	166.9	05.8	27	226.9	07.9	87	286.8	10.0
48	48.0	01.7	08	107.9	03.8	68	167.9	05.9	28	227.9	08.0	88	287.8	10.1
49	49.0	01.7	09	108.9	03.8	69	168.9	05.9	29	228.9	08.0	89	288.8	10.1
50	50.0	01.7	10	109.9	03.8	70	169.9	05.9	30	229.9	08.0	90	289.8	10.1
51	51.0	01.8	111	110.9	03.9	171	170.9	06.0	231	230.9	08.1	291	290.8	10.2
52	52.0	01.8	12	111.9	03.9	72	171.9	06.0	32	231.9	08.1	92	291.8	10.2
53	53.0	01.8	13	112.9	03.9	73	172.9	06.0	33	232.9	08.1	93	292.8	10.2
54	54.0	01.9	14	113.9	04.0	74	173.9	06.1	34	233.9	08.2	94	293.8	10.3
55	55.0	01.9	15	114.9	04.0	75	174.9	06.1	35	234.9	08.2	95	294.8	10.3
56	56.0	02.0	16	115.9	04.0	76	175.9	06.1	36	235.9	08.2	96	295.8	10.3
57	57.0	02.0	17	116.9	04.1	77	176.9	06.2	37	236.9	08.3	97	296.8	10.4
58	58.0	02.0	18	117.9	04.1	78	177.9	06.2	38	237.9	08.3	98	297.8	10.4
59	59.0	02.1	19	118.9	04.2	79	178.9	06.2	39	238.9	08.3	99	298.8	10.4
60	60.0	02.1	20	119.9	04.2	80	179.9	06.3	40	239.9	08.4	300	299.8	10.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 88 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 3 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.9	03.2	121	120.8	06.3	181	180.8	09.5	241	240.7	12.6
2	02.0	00.1	62	61.9	03.2	22	121.8	06.4	82	181.8	09.5	42	241.7	12.7
3	03.0	00.2	63	62.9	03.3	23	122.8	06.4	83	182.7	09.6	43	242.7	12.7
4	04.0	00.2	64	63.9	03.3	24	123.8	06.5	84	183.7	09.6	44	243.7	12.8
5	05.0	00.3	65	64.9	03.4	25	124.8	06.5	85	184.7	09.7	45	244.7	12.8
6	06.0	00.3	66	65.9	03.5	26	125.8	06.6	86	185.7	09.7	46	245.7	12.9
7	07.0	00.4	67	66.9	03.5	27	126.8	06.6	87	186.7	09.8	47	246.7	12.9
8	08.0	00.4	68	67.9	03.6	28	127.8	06.7	88	187.7	09.8	48	247.7	13.0
9	09.0	00.5	69	68.9	03.6	29	128.8	06.8	89	188.7	09.9	49	248.7	13.0
10	10.0	00.5	70	69.9	03.7	30	129.8	06.8	90	189.7	09.9	50	249.7	13.1
11	11.0	00.6	71	70.9	03.7	131	130.8	06.9	191	190.7	10.0	251	250.7	13.1
12	12.0	00.6	72	71.9	03.8	32	131.8	06.9	92	191.7	10.0	52	251.7	13.2
13	13.0	00.7	73	72.9	03.8	33	132.8	07.0	93	192.7	10.1	53	252.7	13.2
14	14.0	00.7	74	73.9	03.9	34	133.8	07.0	94	193.7	10.2	54	253.7	13.3
15	15.0	00.8	75	74.9	03.9	35	134.8	07.1	95	194.7	10.2	55	254.7	13.3
16	16.0	00.8	76	75.9	04.0	36	135.8	07.1	96	195.7	10.3	56	255.6	13.4
17	17.0	00.9	77	76.9	04.0	37	136.8	07.2	97	196.7	10.3	57	256.6	13.5
18	18.0	00.9	78	77.9	04.1	38	137.8	07.2	98	197.7	10.4	58	257.6	13.5
19	19.0	01.0	79	78.9	04.1	39	138.8	07.3	99	198.7	10.4	59	258.6	13.6
20	20.0	01.0	80	79.9	04.2	40	139.8	07.3	200	199.7	10.5	60	259.6	13.6
21	21.0	01.1	81	80.9	04.2	141	140.8	07.4	201	200.7	10.5	261	260.6	13.7
22	22.0	01.2	82	81.9	04.3	42	141.8	07.4	02	201.7	10.6	62	261.6	13.7
23	23.0	01.2	83	82.9	04.3	43	142.8	07.5	03	202.7	10.6	63	262.6	13.8
24	24.0	01.3	84	83.9	04.4	44	143.8	07.5	04	203.7	10.7	64	263.6	13.8
25	25.0	01.3	85	84.9	04.4	45	144.8	07.6	05	204.7	10.7	65	264.6	13.9
26	26.0	01.4	86	85.9	04.5	46	145.8	07.6	06	205.7	10.8	66	265.6	13.9
27	27.0	01.4	87	86.9	04.6	47	146.8	07.7	07	206.7	10.8	67	266.6	14.0
28	28.0	01.5	88	87.9	04.6	48	147.8	07.7	08	207.7	10.9	68	267.6	14.0
29	29.0	01.5	89	88.9	04.7	49	148.8	07.8	09	208.7	10.9	69	268.6	14.1
30	30.0	01.6	90	89.9	04.7	50	149.8	07.9	10	209.7	11.0	70	269.6	14.1
31	31.0	01.6	91	90.9	04.8	151	150.8	07.9	211	210.7	11.0	271	270.6	14.2
32	32.0	01.7	92	91.9	04.8	52	151.8	08.0	12	211.7	11.1	72	271.6	14.2
33	33.0	01.7	93	92.9	04.9	53	152.8	08.0	13	212.7	11.1	73	272.6	14.3
34	34.0	01.8	94	93.9	04.9	54	153.8	08.1	14	213.7	11.2	74	273.6	14.3
35	35.0	01.8	95	94.9	05.0	55	154.8	08.1	15	214.7	11.3	75	274.6	14.4
36	36.0	01.9	96	95.9	05.0	56	155.8	08.2	16	215.7	11.3	76	275.6	14.4
37	36.9	01.9	97	96.9	05.1	57	156.8	08.2	17	216.7	11.4	77	276.6	14.5
38	37.9	02.0	98	97.9	05.1	58	157.8	08.3	18	217.7	11.4	78	277.6	14.5
39	38.9	02.0	99	98.9	05.2	59	158.8	08.3	19	218.7	11.5	79	278.6	14.6
40	39.9	02.1	100	99.9	05.2	60	159.8	08.4	20	219.7	11.5	80	279.6	14.7
41	40.9	02.1	101	100.9	05.3	161	160.8	08.4	221	220.7	11.6	281	280.6	14.7
42	41.9	02.2	02	101.9	05.3	62	161.8	08.5	22	221.7	11.6	82	281.6	14.8
43	42.9	02.3	03	102.9	05.4	63	162.8	08.5	23	222.7	11.7	83	282.6	14.8
44	43.9	02.3	04	103.9	05.4	64	163.8	08.6	24	223.7	11.7	84	283.6	14.9
45	44.9	02.4	05	104.9	05.5	65	164.8	08.6	25	224.7	11.8	85	284.6	14.9
46	45.9	02.4	06	105.9	05.5	66	165.8	08.7	26	225.7	11.8	86	285.6	15.0
47	46.9	02.5	07	106.9	05.6	67	166.8	08.7	27	226.7	11.9	87	286.6	15.0
48	47.9	02.5	08	107.9	05.7	68	167.8	08.8	28	227.7	11.9	88	287.6	15.1
49	48.9	02.6	09	108.9	05.7	69	168.8	08.8	29	228.7	12.0	89	288.6	15.1
50	49.9	02.6	10	109.8	05.8	70	169.8	08.9	30	229.7	12.0	90	289.6	15.2
51	50.9	02.7	111	110.8	05.8	171	170.8	08.9	231	230.7	12.1	291	290.6	15.2
52	51.9	02.7	12	111.8	05.9	72	171.8	09.0	32	231.7	12.1	92	291.6	15.3
53	52.9	02.8	13	112.8	05.9	73	172.8	09.1	33	232.7	12.2	93	292.6	15.3
54	53.9	02.8	14	113.8	06.0	74	173.8	09.1	34	233.7	12.2	94	293.6	15.4
55	54.9	02.9	15	114.8	06.0	75	174.8	09.2	35	234.7	12.3	95	294.6	15.4
56	55.9	02.9	16	115.8	06.1	76	175.8	09.2	36	235.7	12.4	96	295.6	15.5
57	56.9	03.0	17	116.8	06.1	77	176.8	09.3	37	236.7	12.4	97	296.6	15.5
58	57.9	03.0	18	117.8	06.2	78	177.8	09.3	38	237.7	12.5	98	297.6	15.6
59	58.9	03.1	19	118.8	06.2	79	178.8	09.4	39	238.7	12.5	99	298.6	15.6
60	59.9	03.1	20	119.8	06.3	80	179.8	09.4	40	239.7	12.6	300	299.6	15.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 4 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.9	04.3	121	120.7	08.4	181	180.6	12.6	241	240.4	16.8
2	02.0	00.1	62	61.8	04.3	22	121.7	08.5	82	181.6	12.7	42	241.4	16.9
3	03.0	00.2	63	62.8	04.4	23	122.7	08.6	83	182.6	12.8	43	242.4	17.0
4	04.0	00.3	64	63.8	04.5	24	123.7	08.6	84	183.6	12.8	44	243.4	17.0
5	05.0	00.3	65	64.8	04.5	25	124.7	08.7	85	184.5	12.9	45	244.4	17.1
6	06.0	00.4	66	65.8	04.6	26	125.7	08.8	86	185.5	13.0	46	245.4	17.2
7	07.0	00.5	67	66.8	04.7	27	126.7	08.9	87	186.5	13.0	47	246.4	17.2
8	08.0	00.6	68	67.8	04.7	28	127.7	08.9	88	187.5	13.1	48	247.4	17.3
9	09.0	00.6	69	68.8	04.8	29	128.7	09.0	89	188.5	13.2	49	248.4	17.4
10	10.0	00.7	70	69.8	04.9	30	129.7	09.1	90	189.5	13.3	50	249.4	17.4
11	11.0	00.8	71	70.8	05.0	131	130.7	09.1	191	190.5	13.3	251	250.4	17.5
12	12.0	00.8	72	71.8	05.0	32	131.7	09.2	92	191.5	13.4	52	251.4	17.6
13	13.0	00.9	73	72.8	05.1	33	132.7	09.3	93	192.5	13.5	53	252.4	17.6
14	14.0	01.0	74	73.8	05.2	34	133.7	09.3	94	193.5	13.5	54	253.4	17.7
15	15.0	01.0	75	74.8	05.2	35	134.7	09.4	95	194.5	13.6	55	254.4	17.8
16	16.0	01.1	76	75.8	05.3	36	135.7	09.5	96	195.5	13.7	56	255.4	17.9
17	17.0	01.2	77	76.8	05.4	37	136.7	09.6	97	196.5	13.7	57	256.4	17.9
18	18.0	01.3	78	77.8	05.4	38	137.7	09.6	98	197.5	13.8	58	257.4	18.0
19	19.0	01.3	79	78.8	05.5	39	138.7	09.7	99	198.5	13.9	59	258.4	18.1
20	20.0	01.4	80	79.8	05.6	40	139.7	09.8	200	199.5	14.0	60	259.4	18.1
21	20.9	01.5	81	80.8	05.7	141	140.7	09.8	201	200.5	14.0	261	260.4	18.2
22	21.9	01.5	82	81.8	05.7	42	141.7	09.9	02	201.5	14.1	62	261.4	18.3
23	22.9	01.6	83	82.8	05.8	43	142.7	10.0	03	202.5	14.2	63	262.4	18.3
24	23.9	01.7	84	83.8	05.9	44	143.6	10.0	04	203.5	14.2	64	263.4	18.4
25	24.9	01.7	85	84.8	05.9	45	144.6	10.1	05	204.5	14.3	65	264.4	18.5
26	25.9	01.8	86	85.8	06.0	46	145.6	10.2	06	205.5	14.4	66	265.4	18.6
27	26.9	01.9	87	86.8	06.1	47	146.6	10.3	07	206.5	14.4	67	266.3	18.6
28	27.9	02.0	88	87.8	06.1	48	147.6	10.3	08	207.5	14.5	68	267.3	18.7
29	28.9	02.0	89	88.8	06.2	49	148.6	10.4	09	208.5	14.6	69	268.3	18.8
30	29.9	02.1	90	89.8	06.3	50	149.6	10.5	10	209.5	14.6	70	269.3	18.8
31	30.9	02.2	91	90.8	06.3	151	150.6	10.5	211	210.5	14.7	271	270.3	18.9
32	31.9	02.2	92	91.8	06.4	52	151.6	10.6	12	211.5	14.8	72	271.3	19.0
33	32.9	02.3	93	92.8	06.5	53	152.6	10.7	13	212.5	14.9	73	272.3	19.0
34	33.9	02.4	94	93.8	06.6	54	153.6	10.7	14	213.5	14.9	74	273.3	19.1
35	34.9	02.4	95	94.8	06.6	55	154.6	10.8	15	214.5	15.0	75	274.3	19.2
36	35.9	02.5	96	95.8	06.7	56	155.6	10.9	16	215.5	15.1	76	275.3	19.3
37	36.9	02.6	97	96.8	06.8	57	156.6	11.0	17	216.5	15.1	77	276.3	19.3
38	37.9	02.7	98	97.8	06.8	58	157.6	11.0	18	217.5	15.2	78	277.3	19.4
39	38.9	02.7	99	98.8	06.9	59	158.6	11.1	19	218.5	15.3	79	278.3	19.5
40	39.9	02.8	100	99.8	07.0	60	159.6	11.2	20	219.5	15.3	80	279.3	19.5
41	40.9	02.9	101	100.8	07.0	161	160.6	11.2	221	220.5	15.4	281	280.3	19.6
42	41.9	02.9	02	101.8	07.1	62	161.6	11.3	22	221.5	15.5	82	281.3	19.7
43	42.9	03.0	03	102.7	07.2	63	162.6	11.4	23	222.5	15.6	83	282.3	19.7
44	43.9	03.1	04	103.7	07.3	64	163.6	11.4	24	223.5	15.6	84	283.3	19.8
45	44.9	03.1	05	104.7	07.3	65	164.6	11.5	25	224.5	15.7	85	284.3	19.9
46	45.9	03.2	06	105.7	07.4	66	165.6	11.6	26	225.4	15.6	86	285.3	20.0
47	46.9	03.3	07	106.7	07.5	67	166.6	11.6	27	226.4	15.8	87	286.3	20.0
48	47.9	03.3	08	107.7	07.5	68	167.6	11.7	28	227.4	15.9	88	287.3	20.1
49	48.9	03.4	09	108.7	07.6	69	168.6	11.8	29	228.4	16.0	89	288.3	20.2
50	49.9	03.5	10	109.7	07.7	70	169.6	11.9	30	229.4	16.0	90	289.3	20.2
51	50.9	03.6	111	110.7	07.7	171	170.6	11.9	231	230.4	16.1	291	290.3	20.3
52	51.9	03.6	12	111.7	07.8	72	171.6	12.0	32	231.4	16.2	92	291.3	20.4
53	52.9	03.7	13	112.7	07.9	73	172.6	12.1	33	232.4	16.3	93	292.3	20.4
54	53.9	03.8	14	113.7	08.0	74	173.6	12.1	34	233.4	16.3	94	293.3	20.5
55	54.9	03.8	15	114.7	08.0	75	174.6	12.2	35	234.4	16.4	95	294.3	20.6
56	55.9	03.9	16	115.7	08.1	76	175.6	12.3	36	235.4	16.5	96	295.3	20.6
57	56.9	04.0	17	116.7	08.2	77	176.6	12.3	37	236.4	16.5	97	296.3	20.7
58	57.9	04.0	18	117.7	08.2	78	177.6	12.4	38	237.4	16.6	98	297.3	20.8
59	58.9	04.1	19	118.7	08.3	79	178.6	12.5	39	238.4	16.7	99	298.3	20.9
60	59.9	04.2	20	119.7	08.4	80	179.6	12.6	40	239.4	16.7	300	299.3	20.9
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 5 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.8	05.3	121	120.5	10.5	181	180.3	15.8	241	240.1	21.0
2	02.0	00.2	62	61.8	05.4	22	121.5	10.6	82	181.3	15.9	42	241.1	21.1
3	03.0	00.3	63	62.8	05.5	23	122.5	10.7	83	182.3	15.9	43	242.1	21.2
4	04.0	00.3	64	63.8	05.6	24	123.5	10.8	84	183.3	16.0	44	243.1	21.3
5	05.0	00.4	65	64.8	05.7	25	124.5	10.9	85	184.3	16.1	45	244.1	21.4
6	06.0	00.5	66	65.7	05.8	26	125.5	11.0	86	185.3	16.2	46	245.1	21.4
7	07.0	00.6	67	66.7	05.8	27	126.5	11.1	87	186.3	16.3	47	246.1	21.5
8	08.0	00.7	68	67.7	05.9	28	127.5	11.2	88	187.3	16.4	48	247.1	21.6
9	09.0	00.8	69	68.7	06.0	29	128.5	11.2	89	188.3	16.5	49	248.1	21.7
10	10.0	00.9	70	69.7	06.1	30	129.5	11.3	90	189.3	16.6	50	249.0	21.8
11	11.0	01.0	71	70.7	06.2	131	130.5	11.4	191	190.3	16.6	251	250.0	21.9
12	12.0	01.0	72	71.7	06.3	32	131.5	11.5	92	191.3	16.7	52	251.0	22.0
13	13.0	01.1	73	72.7	06.4	33	132.5	11.6	93	192.3	16.8	53	252.0	22.1
14	13.9	01.2	74	73.7	06.4	34	133.5	11.7	94	193.3	16.9	54	253.0	22.1
15	14.9	01.3	75	74.7	06.5	35	134.5	11.8	95	194.3	17.0	55	254.0	22.2
16	15.9	01.4	76	75.7	06.6	36	135.5	11.9	96	195.3	17.1	56	255.0	22.3
17	16.9	01.5	77	76.7	06.7	37	136.5	11.9	97	196.3	17.2	57	256.0	22.4
18	17.9	01.6	78	77.7	06.8	38	137.5	12.0	98	197.2	17.3	58	257.0	22.5
19	18.9	01.7	79	78.7	06.9	39	138.5	12.1	99	198.2	17.3	59	258.0	22.6
20	19.9	01.7	80	79.7	07.0	40	139.5	12.2	200	199.2	17.4	60	259.0	22.7
21	20.9	01.8	81	80.7	07.1	141	140.5	12.3	201	200.2	17.5	261	260.0	22.7
22	21.9	01.9	82	81.7	07.1	42	141.5	12.4	02	201.2	17.6	62	261.0	22.8
23	22.9	02.0	83	82.7	07.2	43	142.5	12.5	03	202.2	17.7	63	262.0	22.9
24	23.9	02.1	84	83.7	07.3	44	143.5	12.6	04	203.2	17.8	64	263.0	23.0
25	24.9	02.2	85	84.7	07.4	45	144.4	12.6	05	204.2	17.9	65	264.0	23.1
26	25.9	02.3	86	85.7	07.5	46	145.4	12.7	06	205.2	18.0	66	265.0	23.2
27	26.9	02.4	87	86.7	07.6	47	146.4	12.8	07	206.2	18.0	67	266.0	23.3
28	27.9	02.4	88	87.7	07.7	48	147.4	12.9	08	207.2	18.1	68	267.0	23.4
29	28.9	02.5	89	88.7	07.8	49	148.4	13.0	09	208.2	18.2	69	268.0	23.4
30	29.9	02.6	90	89.7	07.8	50	149.4	13.1	10	209.2	18.3	70	269.0	23.5
31	30.9	02.7	91	90.7	07.9	151	150.4	13.2	211	210.2	18.4	271	270.0	23.6
32	31.9	02.8	92	91.6	08.0	52	151.4	13.2	12	211.2	18.5	72	271.0	23.7
33	32.9	02.9	93	92.6	08.1	53	152.4	13.3	13	212.2	18.6	73	272.0	23.8
34	33.9	03.0	94	93.6	08.2	54	153.4	13.4	14	213.2	18.7	74	273.0	23.9
35	34.9	03.1	95	94.6	08.3	55	154.4	13.5	15	214.2	18.7	75	274.0	24.0
36	35.9	03.1	96	95.6	08.4	56	155.4	13.6	16	215.2	18.8	76	274.9	24.1
37	36.9	03.2	97	96.6	08.5	57	156.4	13.7	17	216.2	18.9	77	275.9	24.1
38	37.9	03.3	98	97.6	08.5	58	157.4	13.8	18	217.2	19.0	78	276.9	24.2
39	38.9	03.4	99	98.6	08.6	59	158.4	13.9	19	218.2	19.1	79	277.9	24.3
40	39.8	03.5	100	99.6	08.7	60	159.4	13.9	20	219.2	19.2	80	278.9	24.4
41	40.8	03.6	101	100.6	08.8	161	160.4	14.0	221	220.2	19.3	281	279.9	24.5
42	41.8	03.7	02	101.6	08.9	62	161.4	14.1	22	221.2	19.3	82	280.9	24.6
43	42.8	03.7	03	102.6	09.0	63	162.4	14.2	23	222.2	19.4	83	281.9	24.7
44	43.8	03.8	04	103.6	09.1	64	163.4	14.3	24	223.1	19.5	84	282.9	24.8
45	44.8	03.9	05	104.6	09.2	65	164.4	14.4	25	224.1	19.6	85	283.9	24.8
46	45.8	04.0	06	105.6	09.2	66	165.4	14.5	26	225.1	19.7	86	284.9	24.9
47	46.8	04.1	07	106.6	09.3	67	166.4	14.6	27	226.1	19.8	87	285.9	25.0
48	47.8	04.2	08	107.6	09.4	68	167.4	14.6	28	227.1	19.9	88	286.9	25.1
49	48.8	04.3	09	108.6	09.5	69	168.4	14.7	29	228.1	20.0	89	287.9	25.2
50	49.8	04.4	10	109.6	09.6	70	169.4	14.8	30	229.1	20.0	90	288.9	25.3
51	50.8	04.4	111	110.6	09.7	171	170.3	14.9	231	230.1	20.1	291	289.9	25.4
52	51.8	04.5	12	111.6	09.8	72	171.3	15.0	32	231.1	20.2	92	290.9	25.4
53	52.8	04.6	13	112.6	09.8	73	172.3	15.1	33	232.1	20.3	93	291.9	25.5
54	53.8	04.7	14	113.6	09.9	74	173.3	15.2	34	233.1	20.4	94	292.9	25.6
55	54.8	04.8	15	114.6	10.0	75	174.3	15.3	35	234.1	20.5	95	293.9	25.7
56	55.8	04.9	16	115.6	10.1	76	175.3	15.3	36	235.1	20.6	96	294.9	25.8
57	56.8	05.0	17	116.6	10.2	77	176.3	15.4	37	236.1	20.7	97	295.9	25.9
58	57.8	05.1	18	117.6	10.3	78	177.3	15.5	38	237.1	20.7	98	296.9	26.0
59	58.8	05.1	19	118.5	10.4	79	178.3	15.6	39	238.1	20.8	99	297.9	26.1
60	59.8	05.2	20	119.5	10.5	80	179.3	15.7	40	239.1	20.9	300	298.9	26.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 6 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.7	06.4	121	120.3	12.6	181	180.0	18.9	241	239.7	25.2
2	02.0	00.2	62	61.7	06.5	22	121.3	12.8	82	181.0	19.0	42	240.7	25.3
3	03.0	00.3	63	62.7	06.6	23	122.3	12.9	83	182.0	19.1	43	241.7	25.4
4	04.0	00.4	64	63.6	06.7	24	123.3	13.0	84	183.0	19.2	44	242.7	25.5
5	05.0	00.5	65	64.6	06.8	25	124.3	13.1	85	184.0	19.3	45	243.7	25.6
6	06.0	00.6	66	65.6	06.9	26	125.3	13.2	86	185.0	19.4	46	244.7	25.7
7	07.0	00.7	67	66.6	07.0	27	126.3	13.3	87	186.0	19.5	47	245.6	25.8
8	08.0	00.8	68	67.6	07.1	28	127.3	13.4	88	187.0	19.7	48	246.6	25.9
9	09.0	00.9	69	68.6	07.2	29	128.3	13.5	89	188.0	19.8	49	247.6	26.0
10	09.9	01.0	70	69.6	07.3	30	129.3	13.6	90	189.0	19.9	50	248.6	26.1
11	10.9	01.1	71	70.6	07.4	131	130.3	13.7	191	190.0	20.0	251	249.6	26.2
12	11.9	01.3	72	71.6	07.5	32	131.3	13.8	92	190.9	20.1	52	250.6	26.3
13	12.9	01.4	73	72.6	07.6	33	132.3	13.9	93	191.9	20.2	53	251.6	26.4
14	13.9	01.5	74	73.6	07.7	34	133.3	14.0	94	192.9	20.3	54	252.6	26.6
15	14.9	01.6	75	74.6	07.8	35	134.3	14.1	95	193.9	20.4	55	253.6	26.7
16	15.9	01.7	76	75.6	07.9	36	135.3	14.2	96	194.9	20.5	56	254.6	26.8
17	16.9	01.8	77	76.6	08.0	37	136.2	14.3	97	195.9	20.6	57	255.6	26.9
18	17.9	01.9	78	77.6	08.2	38	137.2	14.4	98	196.9	20.7	58	256.6	27.0
19	18.9	02.0	79	78.6	08.3	39	138.2	14.5	99	197.9	20.8	59	257.6	27.1
20	19.9	02.1	80	79.6	08.4	40	139.2	14.6	200	198.9	20.9	60	258.6	27.2
21	20.9	02.2	81	80.6	08.5	141	140.2	14.7	201	199.9	21.0	261	259.6	27.3
22	21.9	02.3	82	81.6	08.6	42	141.2	14.8	02	200.9	21.1	62	260.6	27.4
23	22.9	02.4	83	82.5	08.7	43	142.2	14.9	03	201.9	21.2	63	261.6	27.5
24	23.9	02.5	84	83.5	08.8	44	143.2	15.1	04	202.9	21.3	64	262.6	27.6
25	24.9	02.6	85	84.5	08.9	45	144.2	15.2	05	203.9	21.4	65	263.5	27.7
26	25.9	02.7	86	85.5	09.0	46	145.2	15.3	06	204.9	21.5	66	264.5	27.8
27	26.9	02.8	87	86.5	09.1	47	146.2	15.4	07	205.9	21.6	67	265.5	27.9
28	27.8	02.9	88	87.5	09.2	48	147.2	15.5	08	206.9	21.7	68	266.5	28.0
29	28.8	03.0	89	88.5	09.3	49	148.2	15.6	09	207.9	21.8	69	267.5	28.1
30	29.8	03.1	90	89.5	09.4	50	149.2	15.7	10	208.8	22.0	70	268.5	28.2
31	30.8	03.2	91	90.5	09.5	151	150.2	15.8	211	209.8	22.1	271	269.5	28.3
32	31.8	03.3	92	91.5	09.6	52	151.2	15.9	12	210.8	22.2	72	270.5	28.4
33	32.8	03.4	93	92.5	09.7	53	152.2	16.0	13	211.8	22.3	73	271.5	28.5
34	33.8	03.6	94	93.5	09.8	54	153.2	16.1	14	212.8	22.4	74	272.5	28.6
35	34.8	03.7	95	94.5	09.9	55	154.2	16.2	15	213.8	22.5	75	273.5	28.7
36	35.8	03.8	96	95.5	10.0	56	155.1	16.3	16	214.8	22.6	76	274.5	28.8
37	36.8	03.9	97	96.5	10.1	57	156.1	16.4	17	215.8	22.7	77	275.5	29.0
38	37.8	04.0	98	97.5	10.2	58	157.1	16.5	18	216.8	22.8	78	276.5	29.1
39	38.8	04.1	99	98.5	10.3	59	158.1	16.6	19	217.8	22.9	79	277.5	29.2
40	39.8	04.2	100	99.5	10.5	60	159.1	16.7	20	218.8	23.0	80	278.5	29.3
41	40.8	04.3	101	100.4	10.6	161	160.1	16.8	221	219.8	23.1	281	279.5	29.4
42	41.8	04.4	02	101.4	10.7	62	161.1	16.9	22	220.8	23.2	82	280.5	29.5
43	42.8	04.5	03	102.4	10.8	63	162.1	17.0	23	221.8	23.3	83	281.4	29.6
44	43.8	04.6	04	103.4	10.9	64	163.1	17.1	24	222.8	23.4	84	282.4	29.7
45	44.8	04.7	05	104.4	11.0	65	164.1	17.2	25	223.8	23.5	85	283.4	29.8
46	45.7	04.8	06	105.4	11.1	66	165.1	17.4	26	224.8	23.6	86	284.4	29.9
47	46.7	04.9	07	106.4	11.2	67	166.1	17.5	27	225.8	23.7	87	285.4	30.0
48	47.7	05.0	08	107.4	11.3	68	167.1	17.6	28	226.8	23.8	88	286.4	30.1
49	48.7	05.1	09	108.4	11.4	69	168.1	17.7	29	227.7	23.9	89	287.4	30.2
50	49.7	05.2	10	109.4	11.5	70	169.1	17.8	30	228.7	24.0	90	288.4	30.3
51	50.7	05.3	111	110.4	11.6	171	170.1	17.9	231	229.7	24.1	291	289.4	30.4
52	51.7	05.4	12	111.4	11.7	72	171.1	18.0	32	230.7	24.3	92	290.4	30.5
53	52.7	05.5	13	112.4	11.8	73	172.1	18.1	33	231.7	24.4	93	291.4	30.6
54	53.7	05.6	14	113.4	11.9	74	173.0	18.2	34	232.7	24.5	94	292.4	30.7
55	54.7	05.7	15	114.4	12.0	75	174.0	18.3	35	233.7	24.6	95	293.4	30.8
56	55.7	05.9	16	115.4	12.1	76	175.0	18.4	36	234.7	24.7	96	294.4	30.9
57	56.7	06.0	17	116.4	12.2	77	176.0	18.5	37	235.7	24.8	97	295.4	31.0
58	57.7	06.1	18	117.4	12.3	78	177.0	18.6	38	236.7	24.9	98	296.4	31.1
59	58.7	06.2	19	118.3	12.4	79	178.0	18.7	39	237.7	25.0	99	297.4	31.3
60	59.7	06.3	20	119.3	12.5	80	179.0	18.8	40	238.7	25.1	300	298.4	31.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 7 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.5	07.4	121	120.1	14.7	181	179.7	22.1	241	239.2	29.4
2	02.0	00.2	62	61.5	07.6	22	121.1	14.9	82	180.6	22.2	42	240.2	29.5
3	03.0	00.4	63	62.5	07.7	23	122.1	15.0	83	181.6	22.3	43	241.2	29.6
4	04.0	00.5	64	63.5	07.8	24	123.1	15.1	84	182.6	22.4	44	242.2	29.7
5	05.0	00.6	65	64.5	07.9	25	124.1	15.2	85	183.6	22.5	45	243.2	29.9
6	06.0	00.7	66	65.5	08.0	26	125.1	15.4	86	184.6	22.7	46	244.2	30.0
7	06.9	00.9	67	66.5	08.2	27	126.1	15.5	87	185.6	22.8	47	245.2	30.1
8	07.9	01.0	68	67.5	08.3	28	127.0	15.6	88	186.6	22.9	48	246.2	30.2
9	08.9	01.1	69	68.5	08.4	29	128.0	15.7	89	187.6	23.0	49	247.1	30.3
10	09.9	01.2	70	69.5	08.5	30	129.0	15.8	90	188.6	23.2	50	248.1	30.5
11	10.9	01.3	71	70.5	08.7	131	130.0	16.0	191	189.6	23.3	251	249.1	30.6
12	11.9	01.5	72	71.5	08.8	32	131.0	16.1	92	190.6	23.4	52	250.1	30.7
13	12.9	01.6	73	72.5	08.9	33	132.0	16.2	93	191.6	23.5	53	251.1	30.8
14	13.9	01.7	74	73.4	09.0	34	133.0	16.3	94	192.6	23.6	54	252.1	31.0
15	14.9	01.8	75	74.4	09.1	35	134.0	16.5	95	193.5	23.8	55	253.1	31.1
16	15.9	01.9	76	75.4	09.3	36	135.0	16.6	96	194.5	23.9	56	254.1	31.2
17	16.9	02.1	77	76.4	09.4	37	136.0	16.7	97	195.5	24.0	57	255.1	31.3
18	17.9	02.2	78	77.4	09.5	38	137.0	16.8	98	196.5	24.1	58	256.1	31.4
19	18.9	02.3	79	78.4	09.6	39	138.0	16.9	99	197.5	24.3	59	257.1	31.6
20	19.9	02.4	80	79.4	09.7	40	139.0	17.1	200	198.5	24.4	60	258.1	31.7
21	20.8	02.6	81	80.4	09.9	141	139.9	17.2	201	199.5	24.5	261	259.1	31.8
22	21.8	02.7	82	81.4	10.0	42	140.9	17.3	02	200.5	24.6	62	260.0	31.9
23	22.8	02.8	83	82.4	10.1	43	141.9	17.4	03	201.5	24.7	63	261.0	32.1
24	23.8	02.9	84	83.4	10.2	44	142.9	17.5	04	202.5	24.9	64	262.0	32.2
25	24.8	03.0	85	84.4	10.4	45	143.9	17.7	05	203.5	25.0	65	263.0	32.3
26	25.8	03.2	86	85.4	10.5	46	144.9	17.8	06	204.5	25.1	66	264.0	32.4
27	26.8	03.3	87	86.4	10.6	47	145.9	17.9	07	205.5	25.2	67	265.0	32.5
28	27.8	03.4	88	87.3	10.7	48	146.9	18.0	08	206.4	25.3	68	266.0	32.7
29	28.8	03.5	89	88.3	10.8	49	147.9	18.2	09	207.4	25.5	69	267.0	32.8
30	29.8	03.7	90	89.3	11.0	50	148.9	18.3	10	208.4	25.6	70	268.0	32.9
31	30.8	03.8	91	90.3	11.1	151	149.9	18.4	211	209.4	25.7	271	269.0	33.0
32	31.8	03.9	92	91.3	11.2	52	150.9	18.5	12	210.4	25.8	72	270.0	33.1
33	32.8	04.0	93	92.3	11.3	53	151.9	18.6	13	211.4	26.0	73	271.0	33.3
34	33.7	04.1	94	93.3	11.5	54	152.9	18.8	14	212.4	26.1	74	272.0	33.4
35	34.7	04.3	95	94.3	11.6	55	153.8	18.9	15	213.4	26.2	75	273.0	33.5
36	35.7	04.4	96	95.3	11.7	56	154.8	19.0	16	214.4	26.3	76	273.9	33.6
37	36.7	04.5	97	96.3	11.8	57	155.8	19.1	17	215.4	26.4	77	274.9	33.8
38	37.7	04.6	98	97.3	11.9	58	156.8	19.3	18	216.4	26.6	78	275.9	33.9
39	38.7	04.8	99	98.3	12.1	59	157.8	19.4	19	217.4	26.7	79	276.9	34.0
40	39.7	04.9	100	99.3	12.2	60	158.8	19.5	20	218.4	26.8	80	277.9	34.1
41	40.7	05.0	101	100.2	12.3	161	159.8	19.6	221	219.4	26.9	281	278.9	34.2
42	41.7	05.1	02	101.2	12.4	62	160.8	19.7	22	220.3	27.1	82	279.9	34.4
43	42.7	05.2	03	102.2	12.6	63	161.8	19.9	23	221.3	27.2	83	280.9	34.5
44	43.7	05.4	04	103.2	12.7	64	162.8	20.0	24	222.3	27.3	84	281.9	34.6
45	44.7	05.5	05	104.2	12.8	65	163.8	20.1	25	223.3	27.4	85	282.9	34.7
46	45.7	05.6	06	105.2	12.9	66	164.8	20.2	26	224.3	27.5	86	283.9	34.9
47	46.6	05.7	07	106.2	13.0	67	165.8	20.4	27	225.3	27.7	87	284.9	35.0
48	47.6	05.8	08	107.2	13.2	68	166.7	20.5	28	226.3	27.8	88	285.9	35.1
49	48.6	06.0	09	108.2	13.3	69	167.7	20.6	29	227.3	27.9	89	286.8	35.2
50	49.6	06.1	10	109.2	13.4	70	168.7	20.7	30	228.3	28.0	90	287.8	35.3
51	50.6	06.2	111	110.2	13.5	171	169.7	20.8	231	229.3	28.2	291	288.8	35.5
52	51.6	06.3	12	111.2	13.6	72	170.7	21.0	32	230.3	28.3	92	289.8	35.6
53	52.6	06.5	13	112.2	13.8	73	171.7	21.1	33	231.3	28.4	93	290.8	35.7
54	53.6	06.6	14	113.2	13.9	74	172.7	21.2	34	232.3	28.5	94	291.8	35.8
55	54.6	06.7	15	114.1	14.0	75	173.7	21.3	35	233.2	28.6	95	292.8	36.0
56	55.6	06.8	16	115.1	14.1	76	174.7	21.4	36	234.2	28.8	96	293.8	36.1
57	56.6	06.9	17	116.1	14.3	77	175.7	21.6	37	235.2	28.9	97	294.8	36.2
58	57.6	07.1	18	117.1	14.4	78	176.7	21.7	38	236.2	29.0	98	295.8	36.3
59	58.6	07.2	19	118.1	14.5	79	177.7	21.8	39	237.2	29.1	99	296.8	36.4
60	59.6	07.3	20	119.1	14.6	80	178.7	21.9	40	238.2	29.2	300	297.8	36.6
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 83 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 8 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.4	08.5	121	119.8	16.8	181	179.2	25.2	241	238.7	33.5
2	02.0	00.3	62	61.4	08.6	22	120.8	17.0	82	180.2	25.3	42	239.6	33.7
3	03.0	00.4	63	62.4	08.8	23	121.8	17.1	83	181.2	25.5	43	240.6	33.8
4	04.0	00.6	64	63.4	08.9	24	122.8	17.3	84	182.2	25.6	44	241.6	34.0
5	05.0	00.7	65	64.4	09.0	25	123.8	17.4	85	183.2	25.7	45	242.6	34.1
6	05.9	00.8	66	65.4	09.2	26	124.8	17.5	86	184.2	25.9	46	243.6	34.2
7	06.9	01.0	67	66.3	09.3	27	125.8	17.7	87	185.2	26.0	47	244.6	34.4
8	07.9	01.1	68	67.3	09.5	28	126.8	17.8	88	186.2	26.2	48	245.6	34.5
9	08.9	01.3	69	68.3	09.6	29	127.7	18.0	89	187.2	26.3	49	246.6	34.7
10	09.9	01.4	70	69.3	09.7	30	128.7	18.1	90	188.2	26.4	50	247.6	34.8
11	10.9	01.5	71	70.3	09.9	131	129.7	18.2	191	189.1	26.6	251	248.6	34.9
12	11.9	01.7	72	71.3	10.0	32	130.7	18.4	92	190.1	26.7	52	249.5	35.1
13	12.9	01.8	73	72.3	10.2	33	131.7	18.5	93	191.1	26.9	53	250.5	35.2
14	13.9	01.9	74	73.3	10.3	34	132.7	18.6	94	192.1	27.0	54	251.5	35.3
15	14.9	02.1	75	74.3	10.4	35	133.7	18.8	95	193.1	27.1	55	252.5	35.5
16	15.8	02.2	76	75.3	10.6	36	134.7	18.9	96	194.1	27.3	56	253.5	35.6
17	16.8	02.4	77	76.3	10.7	37	135.7	19.1	97	195.1	27.4	57	254.5	35.8
18	17.8	02.5	78	77.2	10.9	38	136.7	19.2	98	196.1	27.6	58	255.5	35.9
19	18.8	02.6	79	78.2	11.0	39	137.7	19.3	99	197.1	27.7	59	256.5	36.0
20	19.8	02.8	80	79.2	11.1	40	138.6	19.5	200	198.1	27.8	60	257.5	36.2
21	20.8	02.9	81	80.2	11.3	141	139.6	19.6	201	199.0	28.0	261	258.5	36.3
22	21.8	03.1	82	81.2	11.4	42	140.6	19.8	02	200.0	28.1	62	259.5	36.5
23	22.8	03.2	83	82.2	11.6	43	141.6	19.9	03	201.0	28.3	63	260.4	36.6
24	23.8	03.3	84	83.2	11.7	44	142.6	20.0	04	202.0	28.4	64	261.4	36.7
25	24.8	03.5	85	84.2	11.8	45	143.6	20.2	05	203.0	28.5	65	262.4	36.9
26	25.7	03.6	86	85.2	12.0	46	144.6	20.3	06	204.0	28.7	66	263.4	37.0
27	26.7	03.8	87	86.2	12.1	47	145.6	20.5	07	205.0	28.8	67	264.4	37.2
28	27.7	03.9	88	87.1	12.2	48	146.6	20.6	08	206.0	28.9	68	265.4	37.3
29	28.7	04.0	89	88.1	12.4	49	147.5	20.7	09	207.0	29.1	69	266.4	37.4
30	29.7	04.2	90	89.1	12.5	50	148.5	20.9	10	208.0	29.2	70	267.4	37.6
31	30.7	04.3	91	90.1	12.7	151	149.5	21.0	211	208.9	29.4	271	268.4	37.7
32	31.7	04.5	92	91.1	12.8	52	150.5	21.2	12	209.9	29.5	72	269.4	37.9
33	32.7	04.6	93	92.1	12.9	53	151.5	21.3	13	210.9	29.6	73	270.3	38.0
34	33.7	04.7	94	93.1	13.1	54	152.5	21.4	14	211.9	29.8	74	271.3	38.1
35	34.7	04.9	95	94.1	13.2	55	153.5	21.6	15	212.9	29.9	75	272.3	38.3
36	35.6	05.0	96	95.1	13.4	56	154.5	21.7	16	213.9	30.1	76	273.3	38.4
37	36.6	05.1	97	96.1	13.5	57	155.5	21.9	17	214.9	30.2	77	274.3	38.6
38	37.6	05.3	98	97.0	13.6	58	156.5	22.0	18	215.9	30.3	78	275.3	38.7
39	38.6	05.4	99	98.0	13.8	59	157.5	22.1	19	216.9	30.5	79	276.3	38.8
40	39.6	05.6	100	99.0	13.9	60	158.4	22.3	20	217.9	30.6	80	277.3	39.0
41	40.6	05.7	101	100.0	14.1	161	159.4	22.4	221	218.8	30.8	281	278.3	39.1
42	41.6	05.8	02	101.0	14.2	62	160.4	22.5	22	219.8	30.9	82	279.3	39.2
43	42.6	06.0	03	102.0	14.3	63	161.4	22.7	23	220.8	31.0	83	280.2	39.4
44	43.6	06.1	04	103.0	14.5	64	162.4	22.8	24	221.8	31.2	84	281.2	39.5
45	44.6	06.3	05	104.0	14.6	65	163.4	23.0	25	222.8	31.3	85	282.2	39.7
46	45.6	06.4	06	105.0	14.8	66	164.4	23.1	26	223.8	31.5	86	283.2	39.8
47	46.5	06.5	07	106.0	14.9	67	165.4	23.2	27	224.8	31.6	87	284.2	39.9
48	47.5	06.7	08	106.9	15.0	68	166.4	23.4	28	225.8	31.7	88	285.2	40.1
49	48.5	06.8	09	107.9	15.2	69	167.4	23.5	29	226.8	31.9	89	286.2	40.2
50	49.5	07.0	10	108.9	15.3	70	168.3	23.7	30	227.8	32.0	90	287.2	40.4
51	50.5	07.1	111	109.9	15.4	171	169.3	23.8	231	228.8	32.1	291	288.2	40.5
52	51.5	07.2	12	110.9	15.6	72	170.3	23.9	32	229.7	32.3	92	289.2	40.6
53	52.5	07.4	13	111.9	15.7	73	171.3	24.1	33	230.7	32.4	93	290.1	40.8
54	53.5	07.5	14	112.9	15.9	74	172.3	24.2	34	231.7	32.6	94	291.1	40.9
55	54.5	07.7	15	113.9	16.0	75	173.3	24.4	35	232.7	32.7	95	292.1	41.1
56	55.5	07.8	16	114.9	16.1	76	174.3	24.5	36	233.7	32.8	96	293.1	41.2
57	56.4	07.9	17	115.9	16.3	77	175.3	24.6	37	234.7	33.0	97	294.1	41.3
58	57.4	08.1	18	116.9	16.4	78	176.3	24.8	38	235.7	33.1	98	295.1	41.5
59	58.4	08.2	19	117.8	16.6	79	177.3	24.9	39	236.7	33.3	99	296.1	41.6
60	59.4	08.4	20	118.8	16.7	80	178.2	25.1	40	237.7	33.4	300	297.1	41.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II

Difference of Latitude and Departure for 9 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	60.2	09.5	121	119.5	18.9	181	178.8	28.3	241	238.0	37.7
2	02.0	00.3	62	61.2	09.7	22	120.5	19.1	82	179.8	28.5	42	239.0	37.9
3	03.0	00.5	63	62.2	09.9	23	121.5	19.2	83	180.7	28.6	43	240.0	38.0
4	04.0	00.6	64	63.2	10.0	24	122.5	19.4	84	181.7	28.8	44	241.0	38.2
5	04.9	00.8	65	64.2	10.2	25	123.5	19.6	85	182.7	28.9	45	242.0	38.3
6	05.9	00.9	66	65.2	10.3	26	124.4	19.7	86	183.7	29.1	46	243.0	38.5
7	06.9	01.1	67	66.2	10.5	27	125.4	19.9	87	184.7	29.3	47	244.0	38.6
8	07.9	01.3	68	67.2	10.6	28	126.4	20.0	88	185.7	29.4	48	244.9	38.8
9	08.9	01.4	69	68.2	10.8	29	127.4	20.2	89	186.7	29.6	49	245.9	39.0
10	09.9	01.6	70	69.1	11.0	30	128.4	20.3	90	187.7	29.7	50	246.9	39.1
11	10.9	01.7	71	70.1	11.1	131	129.4	20.5	191	188.6	29.9	251	247.9	39.3
12	11.9	01.9	72	71.1	11.3	32	130.4	20.6	92	189.6	30.0	52	248.9	39.4
13	12.8	02.0	73	72.1	11.4	33	131.4	20.8	93	190.6	30.2	53	249.9	39.6
14	13.8	02.2	74	73.1	11.6	34	132.4	21.0	94	191.6	30.3	54	250.9	39.7
15	14.8	02.3	75	74.1	11.7	35	133.3	21.1	95	192.6	30.5	55	251.9	39.9
16	15.8	02.5	76	75.1	11.9	36	134.3	21.3	96	193.6	30.7	56	252.8	40.0
17	16.8	02.7	77	76.1	12.0	37	135.3	21.4	97	194.6	30.8	57	253.8	40.2
18	17.8	02.8	78	77.0	12.2	38	136.3	21.6	98	195.6	31.0	58	254.8	40.4
19	18.8	03.0	79	78.0	12.4	39	137.3	21.7	99	196.5	31.1	59	255.8	40.5
20	19.8	03.1	80	79.0	12.5	40	138.3	21.9	200	197.5	31.3	60	256.8	40.7
21	20.7	03.3	81	80.0	12.7	141	139.3	22.1	201	198.5	31.4	261	257.8	40.8
22	21.7	03.4	82	81.0	12.8	42	140.3	22.2	02	199.5	31.6	62	258.8	41.0
23	22.7	03.6	83	82.0	13.0	43	141.2	22.4	03	200.5	31.8	63	259.8	41.1
24	23.7	03.8	84	83.0	13.1	44	142.2	22.5	04	201.5	31.9	64	260.7	41.3
25	24.7	03.9	85	84.0	13.3	45	143.2	22.7	05	202.5	32.1	65	261.7	41.5
26	25.7	04.1	86	84.9	13.5	46	144.2	22.8	06	203.5	32.2	66	262.7	41.6
27	26.7	04.2	87	85.9	13.6	47	145.2	23.0	07	204.5	32.4	67	263.7	41.8
28	27.7	04.4	88	86.9	13.8	48	146.2	23.2	08	205.4	32.5	68	264.7	41.9
29	28.6	04.5	89	87.9	13.9	49	147.2	23.3	09	206.4	32.7	69	265.7	42.1
30	29.6	04.7	90	88.9	14.1	50	148.2	23.5	10	207.4	32.9	70	266.7	42.2
31	30.6	04.8	91	89.9	14.2	151	149.1	23.6	211	208.4	33.0	271	267.7	42.4
32	31.6	05.0	92	90.9	14.4	52	150.1	23.8	12	209.4	33.2	72	268.7	42.6
33	32.6	05.2	93	91.9	14.5	53	151.1	23.9	13	210.4	33.3	73	269.6	42.7
34	33.6	05.3	94	92.8	14.7	54	152.1	24.1	14	211.4	33.5	74	270.6	42.9
35	34.6	05.5	95	93.8	14.9	55	153.1	24.2	15	212.4	33.6	75	271.6	43.0
36	35.6	05.6	96	94.8	15.0	56	154.1	24.4	16	213.3	33.8	76	272.6	43.2
37	36.5	05.8	97	95.8	15.2	57	155.1	24.6	17	214.3	33.9	77	273.6	43.3
38	37.5	05.9	98	96.8	15.3	58	156.1	24.7	18	215.3	34.1	78	274.6	43.5
39	38.5	06.1	99	97.8	15.5	59	157.0	24.9	19	216.3	34.3	79	275.6	43.6
40	39.5	06.3	100	98.8	15.6	60	158.0	25.0	20	217.3	34.4	80	276.6	43.8
41	40.5	06.4	101	99.8	15.8	161	159.0	25.2	221	218.3	34.6	281	277.5	44.0
42	41.5	06.6	02	100.7	16.0	62	160.0	25.3	22	219.3	34.7	82	278.5	44.1
43	42.5	06.7	03	101.7	16.1	63	161.0	25.5	23	220.3	34.9	83	279.5	44.3
44	43.5	06.9	04	102.7	16.3	64	162.0	25.7	24	221.2	35.0	84	280.5	44.4
45	44.4	07.0	05	103.7	16.4	65	163.0	25.8	25	222.2	35.2	85	281.5	44.6
46	45.4	07.2	06	104.7	16.6	66	164.0	26.0	26	223.2	35.4	86	282.5	44.7
47	46.4	07.4	07	105.7	16.7	67	164.9	26.1	27	224.2	35.5	87	283.5	44.9
48	47.4	07.5	08	106.7	16.9	68	165.9	26.3	28	225.2	35.7	88	284.5	45.1
49	48.4	07.7	09	107.7	17.1	69	166.9	26.4	29	226.2	35.8	89	285.4	45.2
50	49.4	07.8	10	108.6	17.2	70	167.9	26.6	30	227.2	36.0	90	286.4	45.4
51	50.4	08.0	111	109.6	17.4	171	168.9	26.8	231	228.2	36.1	291	287.4	45.5
52	51.4	08.1	12	110.6	17.5	72	169.9	26.9	32	229.1	36.3	92	288.4	45.7
53	52.3	08.3	13	111.6	17.7	73	170.9	27.1	33	230.1	36.4	93	289.4	45.8
54	53.3	08.4	14	112.6	17.8	74	171.9	27.2	34	231.1	36.6	94	290.4	46.0
55	54.3	08.6	15	113.6	18.0	75	172.8	27.4	35	232.1	36.8	95	291.4	46.1
56	55.3	08.8	16	114.6	18.1	76	173.8	27.5	36	233.1	36.9	96	292.4	46.3
57	56.3	08.9	17	115.6	18.3	77	174.8	27.7	37	234.1	37.1	97	293.3	46.5
58	57.3	09.1	18	116.5	18.5	78	175.8	27.8	38	235.1	37.2	98	294.3	46.6
59	58.3	09.2	19	117.5	18.6	79	176.8	28.0	39	236.1	37.4	99	295.3	46.8
60	59.3	09.4	20	118.5	18.8	80	177.8	28.2	40	237.0	37.5	300	296.3	46.9
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 81 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 10 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	60.1	10.6	121	119.2	21.0	181	178.3	31.4	241	237.3	41.8
2	02.0	00.3	62	61.1	10.8	22	120.1	21.2	82	179.2	31.6	42	238.3	42.0
3	03.0	00.5	63	62.0	10.9	23	121.1	21.4	83	180.2	31.8	43	239.3	42.2
4	03.9	00.7	64	63.0	11.1	24	122.1	21.5	84	181.2	32.0	44	240.3	42.4
5	04.9	00.9	65	64.0	11.3	25	123.1	21.7	85	182.2	32.1	45	241.3	42.5
6	05.9	01.0	66	65.0	11.5	26	124.1	21.9	86	183.2	32.3	46	242.3	42.7
7	06.9	01.2	67	66.0	11.6	27	125.1	22.1	87	184.2	32.5	47	243.2	42.9
8	07.9	01.4	68	67.0	11.8	28	126.1	22.2	88	185.1	32.6	48	244.2	43.1
9	08.9	01.6	69	68.0	12.0	29	127.0	22.4	89	186.1	32.8	49	245.2	43.2
10	09.8	01.7	70	68.9	12.2	30	128.0	22.6	90	187.1	33.0	50	246.2	43.4
11	10.8	01.9	71	69.9	12.3	131	129.0	22.7	191	188.1	33.2	251	247.2	43.6
12	11.8	02.1	72	70.9	12.5	32	130.0	22.9	92	189.1	33.3	52	248.2	43.8
13	12.8	02.3	73	71.9	12.7	33	131.0	23.1	93	190.1	33.5	53	249.2	43.9
14	13.8	02.4	74	72.9	12.8	34	132.0	23.3	94	191.1	33.7	54	250.1	44.1
15	14.8	02.6	75	73.9	13.0	35	132.9	23.4	95	192.0	33.9	55	251.1	44.3
16	15.8	02.8	76	74.8	13.2	36	133.9	23.6	96	193.0	34.0	56	252.1	44.5
17	16.7	03.0	77	75.8	13.4	37	134.9	23.8	97	194.0	34.2	57	253.1	44.6
18	17.7	03.1	78	76.8	13.5	38	135.9	24.0	98	195.0	34.4	58	254.1	44.8
19	18.7	03.3	79	77.8	13.7	39	136.9	24.1	99	196.0	34.6	59	255.1	45.0
20	19.7	03.5	80	78.8	13.9	40	137.9	24.3	200	197.0	34.7	60	256.1	45.1
21	20.7	03.6	81	79.8	14.1	141	138.9	24.5	201	197.9	34.9	261	257.0	45.3
22	21.7	03.8	82	80.8	14.2	42	139.8	24.7	02	198.9	35.1	62	258.0	45.5
23	22.7	04.0	83	81.7	14.4	43	140.8	24.8	03	199.9	35.3	63	259.0	45.7
24	23.6	04.2	84	82.7	14.6	44	141.8	25.0	04	200.9	35.4	64	260.0	45.8
25	24.6	04.3	85	83.7	14.8	45	142.8	25.2	05	201.9	35.6	65	261.0	46.0
26	25.6	04.5	86	84.7	14.9	46	143.8	25.4	06	202.9	35.8	66	262.0	46.2
27	26.6	04.7	87	85.7	15.1	47	144.8	25.5	07	203.9	35.9	67	262.9	46.4
28	27.6	04.9	88	86.7	15.3	48	145.8	25.7	08	204.8	36.1	68	263.9	46.5
29	28.6	05.0	89	87.6	15.5	49	146.7	25.9	09	205.8	36.3	69	264.9	46.7
30	29.5	05.2	90	88.6	15.6	50	147.7	26.0	10	206.8	36.5	70	265.9	46.9
31	30.5	05.4	91	89.6	15.8	151	148.7	26.2	211	207.8	36.6	271	266.9	47.1
32	31.5	05.6	92	90.6	16.0	52	149.7	26.4	12	208.8	36.8	72	267.9	47.2
33	32.5	05.7	93	91.6	16.1	53	150.7	26.6	13	209.8	37.0	73	268.9	47.4
34	33.5	05.9	94	92.6	16.3	54	151.7	26.7	14	210.7	37.2	74	269.8	47.6
35	34.5	06.1	95	93.6	16.5	55	152.6	26.9	15	211.7	37.3	75	270.8	47.8
36	35.5	06.3	96	94.5	16.7	56	153.6	27.1	16	212.7	37.5	76	271.8	47.9
37	36.4	06.4	97	95.5	16.8	57	154.6	27.3	17	213.7	37.7	77	272.8	48.1
38	37.4	06.6	98	96.5	17.0	58	155.6	27.4	18	214.7	37.9	78	273.8	48.3
39	38.4	06.8	99	97.5	17.2	59	156.6	27.6	19	215.7	38.0	79	274.8	48.4
40	39.4	06.9	100	98.5	17.4	60	157.6	27.8	20	216.7	38.2	80	275.7	48.6
41	40.4	07.1	101	99.5	17.5	161	158.6	28.0	221	217.6	38.4	281	276.7	48.8
42	41.4	07.3	02	100.5	17.7	62	159.5	28.1	22	218.6	38.5	82	277.7	49.0
43	42.3	07.5	03	101.4	17.9	63	160.5	28.3	23	219.6	38.7	83	278.7	49.1
44	43.3	07.6	04	102.4	18.1	64	161.5	28.5	24	220.6	38.9	84	279.7	49.3
45	44.3	07.8	05	103.4	18.2	65	162.5	28.7	25	221.6	39.1	85	280.7	49.5
46	45.3	08.0	06	104.4	18.4	66	163.5	28.8	26	222.6	39.2	86	281.7	49.7
47	46.3	08.2	07	105.4	18.6	67	164.5	29.0	27	223.6	39.4	87	282.6	49.8
48	47.3	08.3	08	106.4	18.8	68	165.4	29.2	28	224.5	39.6	88	283.6	50.0
49	48.3	08.5	09	107.3	18.9	69	166.4	29.3	29	225.5	39.8	89	284.6	50.2
50	49.2	08.7	10	108.3	19.1	70	167.4	29.5	30	226.5	39.9	90	285.6	50.4
51	50.2	08.9	111	109.3	19.3	171	168.4	29.7	231	227.5	40.1	291	286.6	50.5
52	51.2	09.0	12	110.3	19.4	72	169.4	29.9	32	228.5	40.3	92	287.6	50.7
53	52.2	09.2	13	111.3	19.6	73	170.4	30.0	33	229.5	40.5	93	288.5	50.9
54	53.2	09.4	14	112.3	19.8	74	171.4	30.2	34	230.4	40.6	94	289.5	51.1
55	54.2	09.6	15	113.3	20.0	75	172.3	30.4	35	231.4	40.8	95	290.5	51.2
56	55.1	09.7	16	114.2	20.1	76	173.3	30.6	36	232.4	41.0	96	291.5	51.4
57	56.1	09.9	17	115.2	20.3	77	174.3	30.7	37	233.4	41.2	97	292.5	51.6
58	57.1	10.1	18	116.2	20.5	78	175.3	30.9	38	234.4	41.3	98	293.5	51.7
59	58.1	10.2	19	117.2	20.7	79	176.3	31.1	39	235.4	41.5	99	294.5	51.9
60	59.1	10.4	20	118.2	20.8	80	177.3	31.3	40	236.4	41.7	300	295.4	52.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 11 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	59.9	11.6	121	118.8	23.1	181	177.7	34.5	241	236.6	46.0
2	02.0	00.4	62	60.9	11.8	22	119.8	23.3	82	178.7	34.7	42	237.6	46.2
3	02.9	00.6	63	61.8	12.0	23	120.7	23.5	83	179.6	34.9	43	238.5	46.4
4	03.9	00.8	64	62.8	12.2	24	121.7	23.7	84	180.6	35.1	44	239.5	46.6
5	04.9	01.0	65	63.8	12.4	25	122.7	23.9	85	181.6	35.3	45	240.5	46.7
6	05.9	01.1	66	64.8	12.6	26	123.7	24.0	86	182.6	35.5	46	241.5	46.9
7	06.9	01.3	67	65.8	12.8	27	124.7	24.2	87	183.6	35.7	47	242.5	47.1
8	07.9	01.5	68	66.8	13.0	28	125.6	24.4	88	184.5	35.9	48	243.4	47.3
9	08.8	01.7	69	67.7	13.2	29	126.6	24.6	89	185.5	36.1	49	244.4	47.5
10	09.8	01.9	70	68.7	13.4	30	127.6	24.8	90	186.5	36.3	50	245.4	47.7
11	10.8	02.1	71	69.7	13.5	131	128.6	25.0	191	187.5	36.4	251	246.4	47.9
12	11.8	02.3	72	70.7	13.7	32	129.6	25.2	92	188.5	36.6	52	247.4	48.1
13	12.8	02.5	73	71.7	13.9	33	130.6	25.4	93	189.5	36.8	53	248.4	48.3
14	13.7	02.7	74	72.6	14.1	34	131.5	25.6	94	190.4	37.0	54	249.3	48.5
15	14.7	02.9	75	73.6	14.3	35	132.5	25.8	95	191.4	37.2	55	250.3	48.7
16	15.7	03.1	76	74.6	14.5	36	133.5	26.0	96	192.4	37.4	56	251.3	48.8
17	16.7	03.2	77	75.6	14.7	37	134.5	26.1	97	193.4	37.6	57	252.3	49.0
18	17.7	03.4	78	76.6	14.9	38	135.5	26.3	98	194.4	37.8	58	253.3	49.2
19	18.7	03.6	79	77.5	15.1	39	136.4	26.5	99	195.3	38.0	59	254.2	49.4
20	19.6	03.8	80	78.5	15.3	40	137.4	26.7	200	196.3	38.2	60	255.2	49.6
21	20.6	04.0	81	79.5	15.5	141	138.4	26.9	201	197.3	38.4	261	256.2	49.8
22	21.6	04.2	82	80.5	15.6	42	139.4	27.1	02	198.3	38.5	62	257.2	50.0
23	22.6	04.4	83	81.5	15.8	43	140.4	27.3	03	199.3	38.7	63	258.2	50.2
24	23.6	04.6	84	82.5	16.0	44	141.4	27.5	04	200.3	38.9	64	259.1	50.4
25	24.5	04.8	85	83.4	16.2	45	142.3	27.7	05	201.2	39.1	65	260.1	50.6
26	25.5	05.0	86	84.4	16.4	46	143.3	27.9	06	202.2	39.3	66	261.1	50.8
27	26.5	05.2	87	85.4	16.6	47	144.3	28.0	07	203.2	39.5	67	262.1	50.9
28	27.5	05.3	88	86.4	16.8	48	145.3	28.2	08	204.2	39.7	68	263.1	51 1
29	28.5	05.5	89	87.4	17.0	49	146.3	28.4	09	205.2	39.9	69	264 1	51.3
30	29.4	05.7	90	88.3	17.2	50	147.2	28.6	10	206.1	40.1	70	265.0	51.5
31	30.4	05.9	91	89.3	17.4	151	148.2	28.8	211	207.1	40.3	271	266.0	51.7
32	31.4	06.1	92	90.3	17.6	52	149.2	29.0	12	208.1	40.5	72	267.0	51.9
33	32.4	06.3	93	91.3	17.7	53	150.2	29.2	13	209.1	40.6	73	268.0	52.1
34	33.4	06.5	94	92.3	17.9	54	151.2	29.4	14	210.1	40.8	74	269.0	52.3
35	34.4	06.7	95	93.3	18.1	55	152.2	29.6	15	211.0	41.0	75	269.9	52.5
36	35.3	06.9	96	94.2	18.3	56	153.1	29.8	16	212.0	41.2	76	270.9	52.7
37	36.3	07.1	97	95.2	18.5	57	154.1	30.0	17	213.0	41.4	77	271.9	52.9
38	37.3	07.3	98	96.2	18.7	58	155.1	30.1	18	214.0	41.6	78	272.9	53.0
39	38.3	07.4	99	97.2	18.9	59	156.1	30.3	19	215.0	41.8	79	273.9	53.2
40	39.3	07.6	100	98.2	19.1	60	157.1	30.5	20	216.0	42.0	80	274.9	53.4
41	40.2	07.8	101	99.1	19.3	161	158.0	30.7	221	216.9	42.2	281	275.8	53.6
42	41.2	08.0	02	100.1	19.5	62	159.0	30.9	22	217.9	42.4	82	276.8	53.8
43	42.2	08 2	03	101.1	19.7	63	160.0	31.1	23	218.9	42.6	83	277.8	54.0
44	43.2	08.4	04	102.1	19.8	64	161.0	31.3	24	219.9	42.7	84	278.8	54.2
45	44 2	08.6	05	103.1	20.0	65	162.0	31.5	25	220.9	42.9	85	279.8	54.4
46	45 2	08.8	06	104.1	20.2	66	163.0	31.7	26	221.8	43.1	86	280.7	54.6
47	46.1	09.0	07	105.0	20.4	67	163.9	31.9	27	222.8	43.3	87	281.7	54.8
48	47.1	09.2	08	106.0	20.6	68	164.9	32.1	28	223.8	43.5	88	282.7	55.0
49	48.1	09.3	09	107.0	20.8	69	165.9	32.2	29	224.8	43.7	89	283.7	55.1
50	49.1	09.5	10	108.0	21.0	70	166.9	32.4	30	225.8	43.9	90	284.7	55.3
51	50.1	09.7	111	109.0	21.2	171	167.9	32.6	231	226.8	44.1	291	285 7	55.5
52	51.0	09.9	12	109.9	21.4	72	168.8	32.8	32	227.7	44.3	92	286.6	55.7
53	52.0	10.1	13	110.9	21.6	73	169.8	33.0	33	228.7	44.5	93	287.6	55.9
54	53.0	10.3	14	111.9	21.8	74	170.8	33.2	34	229.7	44.6	94	288.6	56.1
55	54.0	10.5	15	112.9	21.9	75	171.8	33.4	35	230.7	44.8	95	289.6	56.3
56	55.0	10.7	16	113.9	22.1	76	172.8	33.6	36	231.7	45.0	96	290.6	56.5
57	56.0	10.9	17	114.9	22.3	77	173.7	33.8	37	232.6	45.2	97	291.5	56.7
58	56.9	11.1	18	115.8	22.5	78	174.7	34.0	38	233.6	45.4	98	292.5	56.9
59	57.9	11.3	19	116.8	22.7	79	175.7	34.2	39	234.6	45.6	99	293.5	57.1
60	58.9	11.4	20	117.8	22.9	80	176.7	34.3	40	235.6	45.8	300	294.5	57.2
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 12 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	59.7	12.7	121	118.4	25.2	181	177.0	37.6	241	235.7	50.1
2	02.0	00.4	62	60.6	12.9	22	119.3	25.4	82	178.0	37.8	42	236.7	50.3
3	02.9	00.6	63	61.6	13.1	23	120.3	25.6	83	179.0	38.0	43	237.7	50.5
4	03.9	00.8	64	62.6	13.3	24	121.3	25.8	84	180.0	38.3	44	238.7	50.7
5	04.9	01.0	65	63.6	13.5	25	122.3	26.0	85	181.0	38.5	45	239.6	50.9
6	05.9	01.2	66	64.6	13.7	26	123.2	26.2	86	181.9	38.7	46	240.6	51.1
7	06.8	01.5	67	65.5	13.9	27	124.2	26.4	87	182.9	38.9	47	241.6	51.4
8	07.8	01.7	68	66.5	14.1	28	125.2	26.6	88	183.9	39.1	48	242.6	51.6
9	08.8	01.9	69	67.5	14.3	29	126.2	26.8	89	184.9	39.3	49	243.6	51.8
10	09.8	02.1	70	68.5	14.6	30	127.2	27.0	90	185.8	39.5	50	244.5	52.0
11	10.8	02.3	71	69.4	14.8	131	128.1	27.2	191	186.8	39.7	251	245.5	52.2
12	11.7	02.5	72	70.4	15.0	32	129.1	27.4	92	187.8	39.9	52	246.5	52.4
13	12.7	02.7	73	71.4	15.2	33	130.1	27.7	93	188.8	40.1	53	247.5	52.6
14	13.7	02.9	74	72.4	15.4	34	131.1	27.9	94	189.8	40.3	54	248.4	52.8
15	14.7	03.1	75	73.4	15.6	35	132.0	28.1	95	190.7	40.5	55	249.4	53.0
16	15.7	03.3	76	74.3	15.8	36	133.0	28.3	96	191.7	40.8	56	250.4	53.2
17	16.6	03.5	77	75.3	16.0	37	134.0	28.5	97	192.7	41.0	57	251.4	53.4
18	17.6	03.7	78	76.3	16.2	38	135.0	28.7	98	193.7	41.2	58	252.4	53.6
19	18.6	04.0	79	77.3	16.4	39	136.0	28.9	99	194.7	41.4	59	253.3	53.8
20	19.6	04.2	80	78.3	16.6	40	136.9	29.1	200	195.6	41.6	60	254.3	54.1
21	20.5	04.4	81	79.2	16.8	141	137.9	29.3	201	196.6	41.8	261	255.3	54.3
22	21.5	04.6	82	80.2	17.0	42	138.9	29.5	02	197.6	42.0	62	256.3	54.5
23	22.5	04.8	83	81.2	17.3	43	139.9	29.7	03	198.6	42.2	63	257.3	54.7
24	23.5	05.0	84	82.2	17.5	44	140.9	29.9	04	199.5	42.4	64	258.2	54.9
25	24.5	05.2	85	83.1	17.7	45	141.8	30.1	05	200.5	42.6	65	259.2	55.1
26	25.4	05.4	86	84.1	17.9	46	142.8	30.4	06	201.5	42.8	66	260.2	55.3
27	26.4	05.6	87	85.1	18.1	47	143.8	30.6	07	202.5	43.0	67	261.2	55.5
28	27.4	05.8	88	86.1	18.3	48	144.8	30.8	08	203.5	43.2	68	262.1	55.7
29	28.4	06.0	89	87.1	18.5	49	145.7	31.0	09	204.4	43.5	69	263.1	55.9
30	29.3	06.2	90	88.0	18.7	50	146.7	31.2	10	205.4	43.7	70	264.1	56.1
31	30.3	06.4	91	89.0	18.9	151	147.7	31.4	211	206.4	43.9	271	265.1	56.3
32	31.3	06.7	92	90.0	19.1	52	148.7	31.6	12	207.4	44.1	72	266.1	56.6
33	32.3	06.9	93	91.0	19.3	53	149.7	31.8	13	208.3	44.3	73	267.0	56.8
34	33.3	07.1	94	91.9	19.5	54	150.6	32.0	14	209.3	44.5	74	268.0	57.0
35	34.2	07.3	95	92.9	19.8	55	151.6	32.2	15	210.3	44.7	75	269.0	57.2
36	35.2	07.5	96	93.9	20.0	56	152.6	32.4	16	211.3	44.9	76	270.0	57.4
37	36.2	07.7	97	94.9	20.2	57	153.6	32.6	17	212.3	45.1	77	270.9	57.6
38	37.2	07.9	98	95.9	20.4	58	154.5	32.9	18	213.2	45.3	78	271.9	57.8
39	38.1	08.1	99	96.8	20.6	59	155.5	33.1	19	214.2	45.5	79	272.9	58.0
40	39.1	08.3	100	97.8	20.8	60	156.5	33.3	20	215.2	45.7	80	273.9	58.2
41	40.1	08.5	101	98.8	21.0	161	157.5	33.5	221	216.2	45.9	281	274.9	58.4
42	41.1	08.7	02	99.8	21.2	62	158.5	33.7	22	217.1	46.2	82	275.8	58.6
43	42.1	08.9	03	100.7	21.4	63	159.4	33.9	23	218.1	46.4	83	276.8	58.8
44	43.0	09.1	04	101.7	21.6	64	160.4	34.1	24	219.1	46.6	84	277.8	59.0
45	44.0	09.4	05	102.7	21.8	65	161.4	34.3	25	220.1	46.8	85	278.8	59.3
46	45.0	09.6	06	103.7	22.0	66	162.4	34.5	26	221.1	47.0	86	279.8	59.5
47	46.0	09.8	07	104.7	22.2	67	163.4	34.7	27	222.0	47.2	87	280.7	59.7
48	47.0	10.0	08	105.7	22.5	68	164.3	34.9	28	223.0	47.4	88	281.7	59.9
49	47.9	10.2	09	106.6	22.7	69	165.3	35.1	29	224.0	47.6	89	282.7	60.1
50	48.9	10.4	10	107.6	22.9	70	166.3	35.3	30	225.0	47.8	90	283.7	60.3
51	49.9	10.6	111	108.6	23.1	171	167.3	35.6	231	226.0	48.0	291	284.6	60.5
52	50.9	10.8	12	109.6	23.3	72	168.2	35.8	32	226.9	48.2	92	285.6	60.7
53	51.8	11.0	13	110.5	23.5	73	169.2	36.0	33	227.9	48.4	93	286.6	60.9
54	52.8	11.2	14	111.5	23.7	74	170.2	36.2	34	228.9	48.7	94	287.6	61.1
55	53.8	11.4	15	112.5	23.9	75	171.2	36.4	35	229.9	48.9	95	288.6	61.3
56	54.8	11.6	16	113.5	24.1	76	172.2	36.6	36	230.8	49.1	96	289.5	61.5
57	55.8	11.9	17	114.4	24.3	77	173.1	36.8	37	231.8	49.3	97	290.5	61.7
58	56.7	12.1	18	115.4	24.5	78	174.1	37.0	38	232.8	49.5	98	291.5	62.0
59	57.7	12.3	19	116.4	24.7	79	175.1	37.2	39	233.8	49.7	99	292.5	62.2
60	58.7	12.5	20	117.4	24.9	80	176.1	37.4	40	234.8	49.9	300	293.4	62.4
Dist.	Dep.	Lat.	Dist	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 78 Degrees

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 13 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	59.4	13.7	121	117.9	27.2	181	176.4	40.7	241	234.8	54.2
2	01.9	00.4	62	60.4	13.9	22	118.9	27.4	82	177.3	40.9	42	235.8	54.4
3	02.9	00.7	63	61.4	14.2	23	119.8	27.7	83	178.3	41.2	43	236.8	54.7
4	03.9	00.9	64	62.4	14.4	24	120.8	27.9	84	179.3	41.4	44	237.7	54.9
5	04.9	01.1	65	63.3	14.6	25	121.8	28.1	85	180.3	41.6	45	238.7	55.1
6	05.8	01.3	66	64.3	14.8	26	122.8	28.3	86	181.2	41.8	46	239.7	55.3
7	06.8	01.6	67	65.3	15.1	27	123.7	28.6	87	182.2	42.1	47	240.7	55.6
8	07.8	01.8	68	66.3	15.3	28	124.7	28.8	88	183.2	42.3	48	241.6	55.8
9	08.8	02.0	69	67.2	15.5	29	125.7	29.0	89	184.2	42.5	49	242.6	56.0
10	09.7	02.2	70	68.2	15.7	30	126.7	29.2	90	185.1	42.7	50	243.6	56.2
11	10.7	02.5	71	69.2	16.0	131	127.6	29.5	191	186.1	43.0	251	244.6	56.5
12	11.7	02.7	72	70.2	16.2	32	128.6	29.7	92	187.1	43.2	52	245.5	56.7
13	12.7	02.9	73	71.1	16.4	33	129.6	29.9	93	188.1	43.4	53	246.5	56.9
14	13.6	03.1	74	72.1	16.6	34	130.6	30.1	94	189.0	43.6	54	247.5	57.1
15	14.6	03.4	75	73.1	16.9	35	131.5	30.4	95	190.0	43.9	55	248.5	57.4
16	15.6	03.6	76	74.1	17.1	36	132.5	30.6	96	191.0	44.1	56	249.4	57.6
17	16.6	03.8	77	75.0	17.3	37	133.5	30.8	97	192.0	44.3	57	250.4	57.8
18	17.5	04.0	78	76.0	17.5	38	134.5	31.0	98	192.9	44.5	58	251.4	58.0
19	18.5	04.3	79	77.0	17.8	39	135.4	31.3	99	193.9	44.8	59	252.4	58.3
20	19.5	04.5	80	77.9	18.0	40	136.4	31.5	200	194.9	45.0	60	253.3	58.5
21	20.5	04.7	81	78.9	18.2	141	137.4	31.7	201	195.8	45.2	261	254.3	58.7
22	21.4	04.9	82	79.9	18.4	42	138.4	31.9	02	196.8	45.4	62	255.3	58.9
23	22.4	05.2	83	80.9	18.7	43	139.3	32.2	03	197.8	45.7	63	256.3	59.2
24	23.4	05.4	84	81.8	18.9	44	140.3	32.4	04	198.8	45.9	64	257.2	59.4
25	24.4	05.6	85	82.8	19.1	45	141.3	32.6	05	199.7	46.1	65	258.2	59.6
26	25.3	05.8	86	83.8	19.3	46	142.3	32.8	06	200.7	46.3	66	259.2	59.8
27	26.3	06.1	87	84.8	19.6	47	143.2	33.1	07	201.7	46.6	67	260.2	60.1
28	27.3	06.3	88	85.7	19.8	48	144.2	33.3	08	202.7	46.8	68	261.1	60.3
29	28.3	06.5	89	86.7	20.0	49	145.2	33.5	09	203.6	47.0	69	262.1	60.5
30	29.2	06.7	90	87.7	20.2	50	146.2	33.7	10	204.6	47.2	70	263.1	60.7
31	30.2	07.0	91	88.7	20.5	151	147.1	34.0	211	205.6	47.5	271	264.1	61.0
32	31.2	07.2	92	89.6	20.7	52	148.1	34.2	12	206.6	47.7	72	265.0	61.2
33	32.2	07.4	93	90.6	20.9	53	149.1	34.4	13	207.5	47.9	73	266.0	61.4
34	33.1	07.6	94	91.6	21.1	54	150.1	34.6	14	208.5	48.1	74	267.0	61.6
35	34.1	07.9	95	92.6	21.4	55	151.0	34.9	15	209.5	48.4	75	268.0	61.9
36	35.1	08.1	96	93.5	21.6	56	152.0	35.1	16	210.5	48.6	76	268.9	62.1
37	36.1	08.3	97	94.5	21.8	57	153.0	35.3	17	211.4	48.8	77	269.9	62.3
38	37.0	08.5	98	95.5	22.0	58	154.0	35.5	18	212.4	49.0	78	270.9	62.5
39	38.0	08.8	99	96.5	22.3	59	154.9	35.8	19	213.4	49.3	79	271.8	62.8
40	39.0	09.0	100	97.4	22.5	60	155.9	36.0	20	214.4	49.5	80	272.8	63.0
41	39.9	09.2	101	98.4	22.7	161	156.9	36.2	221	215.3	49.7	281	273.8	63.2
42	40.9	09.4	02	99.4	22.9	62	157.8	36.4	22	216.3	49.9	82	274.8	63.4
43	41.9	09.7	03	100.4	23.2	63	158.8	36.7	23	217.3	50.2	83	275.7	63.7
44	42.9	09.9	04	101.3	23.4	64	159.8	36.9	24	218.3	50.4	84	276.7	63.9
45	43.8	10.1	05	102.3	23.6	65	160.8	37.1	25	219.2	50.6	85	277.7	64.1
46	44.8	10.3	06	103.3	23.8	66	161.7	37.3	26	220.2	50.8	86	278.7	64.3
47	45.8	10.6	07	104.3	24.1	67	162.7	37.6	27	221.2	51.1	87	279.6	64.6
48	46.8	10.8	08	105.2	24.3	68	163.7	37.8	28	222.2	51.3	88	280.6	64.8
49	47.7	11.0	09	106.2	24.5	69	164.7	38.0	29	223.1	51.5	89	281.6	65.0
50	48.7	11.2	10	107.2	24.7	70	165.6	38.2	30	224.1	51.7	90	282.6	65.2
51	49.7	11.5	111	108.2	25.0	171	166.6	38.5	231	225.1	52.0	291	283.5	65.5
52	50.7	11.7	12	109.1	25.2	72	167.6	38.7	32	226.1	52.2	92	284.5	65.7
53	51.6	11.9	13	110.1	25.4	73	168.6	38.9	33	227.0	52.4	93	285.5	65.9
54	52.6	12.1	14	111.1	25.6	74	169.5	39.1	34	228.0	52.6	94	286.5	66.1
55	53.6	12.4	15	112.1	25.9	75	170.5	39.4	35	229.0	52.9	95	287.4	66.4
56	54.6	12.6	16	113.0	26.1	76	171.5	39.6	36	230.0	53.1	96	288.4	66.6
57	55.5	12.8	17	114.0	26.3	77	172.5	39.8	37	230.9	53.3	97	289.4	66.8
58	56.5	13.0	18	115.0	26.5	78	173.4	40.0	38	231.9	53.5	98	290.4	67.0
59	57.5	13.3	19	116.0	26.8	79	174.4	40.3	39	232.9	53.8	99	291.3	67.3
60	58.5	13.5	20	116.9	27.0	80	175.4	40.5	40	233.8	54.0	300	292.3	67.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 14 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	59.2	14.8	121	117.4	29.3	181	175.6	43.8	241	233.8	58.3
2	01.9	00.5	62	60.2	15.0	22	118.4	29.5	82	176.6	44.0	42	234.8	58.5
3	02.9	00.7	63	61.1	15.2	23	119.3	29.8	83	177.6	44.3	43	235.8	58.8
4	03.9	01.0	64	62.1	15.5	24	120.3	30.0	84	178.5	44.5	44	236.8	59.0
5	04.9	01.2	65	63.1	15.7	25	121.3	30.2	85	179.5	44.8	45	237.7	59.3
6	05.8	01.5	66	64.0	16.0	26	122.3	30.5	86	180.5	45.0	46	238.7	59.5
7	06.8	01.7	67	65.0	16.2	27	123.2	30.7	87	181.4	45.2	47	239.7	59.8
8	07.8	01.9	68	66.0	16.5	28	124.2	31.0	88	182.4	45.5	48	240.6	60.0
9	08.7	02.2	69	67.0	16.7	29	125.2	31.2	89	183.4	45.7	49	241.6	60.2
10	09.7	02.4	70	67.9	16.9	30	126.1	31.4	90	184.4	46.0	50	242.6	60.5
11	10.7	02.7	71	68.9	17.2	131	127.1	31.7	191	185.3	46.2	251	243.5	60.7
12	11.6	02.9	72	69.9	17.4	32	128.1	31.9	92	186.3	46.4	52	244.5	61.0
13	12.6	03.1	73	70.8	17.7	33	129.0	32.2	93	187.3	46.7	53	245.5	61.2
14	13.6	03.4	74	71.8	17.9	34	130.0	32.4	94	188.2	46.9	54	246.5	61.4
15	14.6	03.6	75	72.8	18.1	35	131.0	32.7	95	189.2	47.2	55	247.4	61.7
16	15.5	03.9	76	73.7	18.4	36	132.0	32.9	96	190.2	47.4	56	248.4	61.9
17	16.5	04.1	77	74.7	18.6	37	132.9	33.1	97	191.1	47.7	57	249.4	62.2
18	17.5	04.4	78	75.7	18.9	38	133.9	33.4	98	192.1	47.9	58	250.3	62.4
19	18.4	04.6	79	76.7	19.1	39	134.9	33.6	99	193.1	48.1	59	251.3	62.7
20	19.4	04.8	80	77.6	19.4	40	135.8	33.9	200	194.1	48.4	60	252.3	62.9
21	20.4	05.1	81	78.6	19.6	141	136.8	34.1	201	195.0	48.6	261	253.2	63.1
22	21.3	05.3	82	79.6	19.8	42	137.8	34.4	02	196.0	48.9	62	254.2	63.4
23	22.3	05.6	83	80.5	20.1	43	138.8	34.6	03	197.0	49.1	63	255.2	63.6
24	23.3	05.8	84	81.5	20.3	44	139.7	34.8	04	197.9	49.4	64	256.2	63.9
25	24.3	06.0	85	82.5	20.6	45	140.7	35.1	05	198.9	49.6	65	257.1	64.1
26	25.2	06.3	86	83.4	20.8	46	141.7	35.3	06	199.9	49.8	66	258.1	64.4
27	26.2	06.5	87	84.4	21.0	47	142.6	35.6	07	200.9	50.1	67	259.1	64.6
28	27.2	06.8	88	85.4	21.3	48	143.6	35.8	08	201.8	50.3	68	260.0	64.8
29	28.1	07.0	89	86.4	21.5	49	144.6	36.0	09	202.8	50.6	69	261.0	65.1
30	29.1	07.3	90	87.3	21.8	50	145.5	36.3	10	203.8	50.8	70	262.0	65.3
31	30.1	07.5	91	88.3	22.0	151	146.5	36.5	211	204.7	51.0	271	263.0	65.6
32	31.0	07.7	92	89.3	22.3	52	147.5	36.8	12	205.7	51.3	72	263.9	65.8
33	32.0	08.0	93	90.2	22.5	53	148.5	37.0	13	206.7	51.5	73	264.9	66.0
34	33.0	08.2	94	91.2	22.7	54	149.4	37.3	14	207.6	51.8	74	265.9	66.3
35	34.0	08.5	95	92.2	23.0	55	150.4	37.5	15	208.6	52.0	75	266.8	66.5
36	34.9	08.7	96	93.1	23.2	56	151.4	37.7	16	209.6	52.3	76	267.8	66.8
37	35.9	09.0	97	94.1	23.5	57	152.3	38.0	17	210.6	52.5	77	268.8	67.0
38	36.9	09.2	98	95.1	23.7	58	153.3	38.2	18	211.5	52.7	78	269.7	67.3
39	37.8	09.4	99	96.1	24.0	59	154.3	38.5	19	212.5	53.0	79	270.7	67.5
40	38.8	09.7	100	97.0	24.2	60	155.2	38.7	20	213.5	53.2	80	271.7	67.7
41	39.8	09.9	101	98.0	24.4	161	156.2	38.9	221	214.4	53.5	281	272.7	68.0
42	40.8	10.2	02	99.0	24.7	62	157.2	39.2	22	215.4	53.7	82	273.6	68.2
43	41.7	10.4	03	99.9	24.9	63	158.2	39.4	23	216.4	53.9	83	274.6	68.5
44	42.7	10.6	04	100.9	25.2	64	159.1	39.7	24	217.3	54.2	84	275.6	68.7
45	43.7	10.9	05	101.9	25.4	65	160.1	39.9	25	218.3	54.4	85	276.5	68.9
46	44.6	11.1	06	102.9	25.6	66	161.1	40.2	26	219.3	54.7	86	277.5	69.2
47	45.6	11.4	07	103.8	25.9	67	162.0	40.4	27	220.3	54.9	87	278.5	69.4
48	46.6	11.6	08	104.8	26.1	68	163.0	40.6	28	221.2	55.2	88	279.4	69.7
49	47.5	11.9	09	105.8	26.4	69	164.0	40.9	29	222.2	55.4	89	280.4	69.9
50	48.5	12.1	10	106.7	26.6	70	165.0	41.1	30	223.2	55.6	90	281.4	70.2
51	49.5	12.3	111	107.7	26.9	171	165.9	41.4	231	224.1	55.9	291	282.4	70.4
52	50.5	12.6	12	108.7	27.1	72	166.9	41.6	32	225.1	56.1	92	283.3	70.6
53	51.4	12.8	13	109.6	27.3	73	167.9	41.9	33	226.1	56.4	93	284.3	70.9
54	52.4	13.1	14	110.6	27.6	74	168.8	42.1	34	227.0	56.6	94	285.3	71.1
55	53.4	13.3	15	111.6	27.8	75	169.8	42.3	35	228.0	56.9	95	286.2	71.4
56	54.3	13.5	16	112.6	28.1	76	170.8	42.6	36	229.0	57.1	96	287.2	71.6
57	55.3	13.8	17	113.5	28.3	77	171.7	42.8	37	230.0	57.3	97	288.2	71.9
58	56.3	14.0	18	114.5	28.5	78	172.7	43.1	38	230.9	57.6	98	289.1	72.1
59	57.2	14.3	19	115.5	28.8	79	173.7	43.3	39	231.9	57.8	99	290.1	72.3
60	58.2	14.5	20	116.4	29.0	80	174.7	43.5	40	232.9	58.1	300	291.1	72.6
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 15 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.3	61	58.9	15.8	121	116.9	31.3	181	174.8	46.8	241	232.8	62.4
2	01.9	00.5	62	59.9	16.0	22	117.8	31.6	82	175.8	47.1	42	233.8	62.6
3	02.9	00.8	63	60.9	16.3	23	118.8	31.8	83	176.8	47.4	43	234.7	62.9
4	03.9	01.0	64	61.8	16.6	24	119.8	32.1	84	177.7	47.6	44	235.7	63.2
5	04.8	01.3	65	62.8	16.8	25	120.7	32.4	85	178.7	47.9	45	236.7	63.4
6	05.8	01.6	66	63.8	17.1	26	121.7	32.6	86	179.7	48.1	46	237.6	63.7
7	06.8	01.8	67	64.7	17.3	27	122.7	32.9	87	180.6	48.4	47	238.6	63.9
8	07.7	02.1	68	65.7	17.6	28	123.6	33.1	88	181.6	48.7	48	239.5	64.2
9	08.7	02.3	69	66.6	17.9	29	124.6	33.4	89	182.6	48.9	49	240.5	64.4
10	09.7	02.6	70	67.6	18.1	30	125.6	33.6	90	183.5	49.2	50	241.5	64.7
11	10.6	02.8	71	68.6	18.4	131	126.5	33.9	191	184.5	49.4	251	242.4	65.0
12	11.6	03.1	72	69.5	18.6	32	127.5	34.2	92	185.5	49.7	52	243.4	65.2
13	12.6	03.4	73	70.5	18.9	33	128.5	34.4	93	186.4	50.0	53	244.4	65.5
14	13.5	03.6	74	71.5	19.2	34	129.4	34.7	94	187.4	50.2	54	245.3	65.7
15	14.5	03.9	75	72.4	19.4	35	130.4	34.9	95	188.4	50.5	55	246.3	66.0
16	15.5	04.1	76	73.4	19.7	36	131.4	35.2	96	189.3	50.7	56	247.3	66.3
17	16.4	04.4	77	74.4	19.9	37	132.3	35.5	97	190.3	51.0	57	248.2	66.5
18	17.4	04.7	78	75.3	20.2	38	133.3	35.7	98	191.3	51.2	58	249.2	66.8
19	18.4	04.9	79	76.3	20.4	39	134.3	36.0	99	192.2	51.5	59	250.2	67.0
20	19.3	05.2	80	77.3	20.7	40	135.2	36.2	200	193.2	51.8	60	251.1	67.3
21	20.3	05.4	81	78.2	21.0	141	136.2	36.5	201	194.2	52.0	261	252.1	67.6
22	21.3	05.7	82	79.2	21.2	42	137.2	36.8	02	195.1	52.3	62	253.1	67.8
23	22.2	06.0	83	80.2	21.5	43	138.1	37.0	03	196.1	52.5	63	254.0	68.1
24	23.2	06.2	84	81.1	21.7	44	139.1	37.3	04	197.0	52.8	64	255.0	68.3
25	24.1	06.5	85	82.1	22.0	45	140.1	37.5	05	198.0	53.1	65	256.0	68.6
26	25.1	06.7	86	83.1	22.3	46	141.0	37.8	06	199.0	53.3	66	256.9	68.8
27	26.1	07.0	87	84.0	22.5	47	142.0	38.0	07	199.9	53.6	67	257.9	69.1
28	27.0	07.2	88	85.0	22.8	48	143.0	38.3	08	200.9	53.8	68	258.9	69.4
29	28.0	07.5	89	86.0	23.0	49	143.9	38.6	09	201.9	54.1	69	259.8	69.6
30	29.0	07.8	90	86.9	23.3	50	144.9	38.8	10	202.8	54.4	70	260.8	69.9
31	29.9	08.0	91	87.9	23.6	151	145.9	39.1	211	203.8	54.6	271	261.8	70.1
32	30.9	08.3	92	88.9	23.8	52	146.8	39.3	12	204.8	54.9	72	262.7	70.4
33	31.9	08.5	93	89.8	24.1	53	147.8	39.6	13	205.7	55.1	73	263.7	70.7
34	32.8	08.8	94	90.8	24.3	54	148.8	39.9	14	206.7	55.4	74	264.7	70.9
35	33.8	09.1	95	91.8	24.6	55	149.7	40.1	15	207.7	55.6	75	265.6	71.2
36	34.8	09.3	96	92.7	24.8	56	150.7	40.4	16	208.6	55.9	76	266.6	71.4
37	35.7	09.6	97	93.7	25.1	57	151.7	40.6	17	209.6	56.2	77	267.6	71.7
38	36.7	09.8	98	94.7	25.4	58	152.6	40.9	18	210.6	56.4	78	268.5	72.0
39	37.7	10.1	99	95.6	25.6	59	153.6	41.2	19	211.5	56.7	79	269.5	72.2
40	38.6	10.4	100	96.6	25.9	60	154.5	41.4	20	212.5	56.9	80	270.5	72.5
41	39.6	10.6	101	97.6	26.1	161	155.5	41.7	221	213.5	57.2	281	271.4	72.7
42	40.6	10.9	02	98.5	26.4	62	156.5	41.9	22	214.4	57.5	82	272.4	73.0
43	41.5	11.1	03	99.5	26.7	63	157.4	42.2	23	215.4	57.7	83	273.4	73.2
44	42.5	11.4	04	100.5	26.9	64	158.4	42.4	24	216.4	58.0	84	274.3	73.5
45	43.5	11.6	05	101.4	27.2	65	159.4	42.7	25	217.3	58.2	85	275.3	73.8
46	44.4	11.9	06	102.4	27.4	66	160.3	43.0	26	218.3	58.5	86	276.3	74.0
47	45.4	12.2	07	103.4	27.7	67	161.3	43.2	27	219.3	58.8	87	277.2	74.3
48	46.4	12.4	08	104.3	28.0	68	162.3	43.5	28	220.2	59.0	88	278.2	74.5
49	47.3	12.7	09	105.3	28.2	69	163.2	43.7	29	221.2	59.3	89	279.2	74.8
50	48.3	12.9	10	106.3	28.5	70	164.2	44.0	30	222.2	59.5	90	280.1	75.1
51	49.3	13.2	111	107.2	28.7	171	165.2	44.3	231	223.1	59.8	291	281.1	75.3
52	50.2	13.5	12	108.2	29.0	72	166.1	44.5	32	224.1	60.0	92	282.1	75.6
53	51.2	13.7	13	109.1	29.2	73	167.1	44.8	33	225.1	60.3	93	283.0	75.8
54	52.2	14.0	14	110.1	29.5	74	168.1	45.0	34	226.0	60.6	94	284.0	76.1
55	53.1	14.2	15	111.1	29.8	75	169.0	45.3	35	227.0	60.8	95	284.9	76.4
56	54.1	14.5	16	112.0	30.0	76	170.0	45.6	36	228.0	61.1	96	285.9	76.6
57	55.1	14.8	17	113.0	30.3	77	171.0	45.8	37	228.9	61.3	97	286.9	76.9
58	56.0	15.0	18	114.0	30.5	78	171.9	46.1	38	229.9	61.6	98	287.8	77.1
59	57.0	15.3	19	114.9	30.8	79	172.9	46.3	39	230.9	61.9	99	288.8	77.4
60	58.0	15.5	20	115.9	31.1	80	173.9	46.6	40	231.8	62.1	300	289.8	77.6
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 16 Degrees

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.3	61	58.6	16.8	121	116.3	33.4	181	174.0	49.9	241	231.7	66.4
2	01.9	00.6	62	59.6	17.1	22	117.3	33.6	82	174.9	50.2	42	232.6	66.7
3	02.9	00.8	63	60.6	17.4	23	118.2	33.9	83	175.9	50.4	43	233.6	67.0
4	03.8	01.1	64	61.5	17.6	24	119.2	34.2	84	176.9	50.7	44	234.5	67.3
5	04.8	01.4	65	62.5	17.9	25	120.2	34.5	85	177.8	51.0	45	235.5	67.5
6	05.8	01.7	66	63.4	18.2	26	121.1	34.7	86	178.8	51.3	46	236.5	67.8
7	06.7	01.9	67	64.4	18.5	27	122.1	35.0	87	179.8	51.5	47	237.4	68.1
8	07.7	02.2	68	65.4	18.7	28	123.0	35.3	88	180.7	51.8	48	238.4	68.4
9	08.7	02.5	69	66.3	19.0	29	124.0	35.6	89	181.7	52.1	49	239.4	68.6
10	09.6	02.8	70	67.3	19.3	30	125.0	35.8	90	182.6	52.4	50	240.3	68.9
11	10.6	03.0	71	68.2	19.6	131	125.9	36.1	191	183.6	52.6	251	241.3	69.2
12	11.5	03.3	72	69.2	19.8	32	126.9	36.4	92	184.6	52.9	52	242.2	69.5
13	12.5	03.6	73	70.2	20.1	33	127.8	36.7	93	185.5	53.2	53	243.2	69.7
14	13.5	03.9	74	71.1	20.4	34	128.8	36.9	94	186.5	53.5	54	244.2	70.0
15	14.4	04.1	75	72.1	20.7	35	129.8	37.2	95	187.4	53.7	55	245.1	70.3
16	15.4	04.4	76	73.1	20.9	36	130.7	37.5	96	188.4	54.0	56	246.1	70.6
17	16.3	04.7	77	74.0	21.2	37	131.7	37.8	97	189.4	54.3	57	247.0	70.8
18	17.3	05.0	78	75.0	21.5	38	132.7	38.0	98	190.3	54.6	58	248.0	71.1
19	18.3	05.2	79	75.9	21.8	39	133.6	38.3	99	191.3	54.9	59	249.0	71.4
20	19.2	05.5	80	76.9	22.1	40	134.6	38.6	200	192.3	55.1	60	249.9	71.7
21	20.2	05.8	81	77.9	22.3	141	135.5	38.9	201	193.2	55.4	261	250.9	71.9
22	21.1	06.1	82	78.8	22.6	42	136.5	39.1	02	194.2	55.7	62	251.9	72.2
23	22.1	06.3	83	79.8	22.9	43	137.5	39.4	03	195.1	56.0	63	252.8	72.5
24	23.1	06.6	84	80.7	23.2	44	138.4	39.7	04	196.1	56.2	64	253.8	72.8
25	24.0	06.9	85	81.7	23.4	45	139.4	40.0	05	197.1	56.5	65	254.7	73.0
26	25.0	07.2	86	82.7	23.7	46	140.3	40.2	06	198.0	56.8	66	255.7	73.3
27	26.0	07.4	87	83.6	24.0	47	141.3	40.5	07	199.0	57.1	67	256.7	73.6
28	26.9	07.7	88	84.6	24.3	48	142.3	40.8	08	199.9	57.3	68	257.6	73.9
29	27.9	08.0	89	85.6	24.5	49	143.2	41.1	09	200.9	57.6	69	258.6	74.1
30	28.8	08.3	90	86.5	24.8	50	144.2	41.3	10	201.9	57.9	70	259.5	74.4
31	29.8	08.5	91	87.5	25.1	151	145.2	41.6	211	202.8	58.2	271	260.5	74.7
32	30.8	08.8	92	88.4	25.4	52	146.1	41.9	12	203.8	58.4	72	261.5	75.0
33	31.7	09.1	93	89.4	25.6	53	147.1	42.2	13	204.7	58.7	73	262.4	75.2
34	32.7	09.4	94	90.4	25.9	54	148.0	42.4	14	205.7	59.0	74	263.4	75.5
35	33.6	09.6	95	91.3	26.2	55	149.0	42.7	15	206.7	59.3	75	264.3	75.8
36	34.6	09.9	96	92.3	26.5	56	150.0	43.0	16	207.6	59.5	76	265.3	76.1
37	35.6	10.2	97	93.2	26.7	57	150.9	43.3	17	208.6	59.8	77	266.3	76.4
38	36.5	10.5	98	94.2	27.0	58	151.9	43.6	18	209.6	60.1	78	267.2	76.6
39	37.5	10.7	99	95.2	27.3	59	152.8	43.8	19	210.5	60.4	79	268.2	76.9
40	38.5	11.0	100	96.1	27.6	60	153.8	44.1	20	211.5	60.6	80	269.2	77.2
41	39.4	11.3	101	97.1	27.8	161	154.8	44.4	221	212.4	60.9	281	270.1	77.5
42	40.4	11.6	02	98.0	28.1	62	155.7	44.7	22	213.4	61.2	82	271.1	77.7
43	41.3	11.9	03	99.0	28.4	63	156.7	44.9	23	214.4	61.5	83	272.0	78.0
44	42.3	12.1	04	100.0	28.7	64	157.6	45.2	24	215.3	61.7	84	273.0	78.3
45	43.3	12.4	05	100.9	28.9	65	158.6	45.5	25	216.3	62.0	85	274.0	78.6
46	44.2	12.7	06	101.9	29.2	66	159.6	45.8	26	217.2	62.3	86	274.9	78.8
47	45.2	13.0	07	102.9	29.5	67	160.5	46.0	27	218.2	62.6	87	275.9	79.1
48	46.1	13.2	08	103.8	29.8	68	161.5	46.3	28	219.2	62.8	88	276.8	79.4
49	47.1	13.5	09	104.8	30.0	69	162.5	46.6	29	220.1	63.1	89	277.8	79.7
50	48.1	13.8	10	105.7	30.3	70	163.4	46.9	30	221.1	63.4	90	278.8	79.9
51	49.0	14.1	111	106.7	30.6	171	164.4	47.1	231	222.1	63.7	291	279.7	80.2
52	50.0	14.3	12	107.7	30.9	72	165.3	47.4	32	223.0	63.9	92	280.7	80.5
53	50.9	14.6	13	108.6	31.1	73	166.3	47.7	33	224.0	64.2	93	281.6	80.8
54	51.9	14.9	14	109.6	31.4	74	167.3	48.0	34	224.9	64.5	94	282.6	81.0
55	52.9	15.2	15	110.5	31.7	75	168.2	48.2	35	225.9	64.8	95	283.6	81.3
56	53.8	15.4	16	111.5	32.0	76	169.2	48.5	36	226.9	65.1	96	284.5	81.6
57	54.8	15.7	17	112.5	32.2	77	170.1	48.8	37	227.8	65.3	97	285.5	81.9
58	55.8	16.0	18	113.4	32.5	78	171.1	49.1	38	228.8	65.6	98	286.5	82.1
59	56.7	16.3	19	114.4	32.8	79	172.1	49.3	39	229.7	65.9	99	287.4	82.4
60	57.7	16.5	20	115.4	33.1	80	173.0	49.6	40	230.7	66.2	300	288.4	82.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 17 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.3	61	58.3	17.8	121	115.7	35.4	181	173.1	52.9	241	230.5	70.5
2	01.9	00.6	62	59.3	18.1	22	116.7	35.7	82	174.0	53.2	42	231.4	70.8
3	02.9	00.9	63	60.2	18.4	23	117.6	36.0	83	175.0	53.5	43	232.4	71.0
4	03.8	01.2	64	61.2	18.7	24	118.6	36.3	84	176.0	53.8	44	233.3	71.3
5	04.8	01.5	65	62.2	19.0	25	119.5	36.5	85	176.9	54.1	45	234.3	71.6
6	05.7	01.8	66	63.1	19.3	26	120.5	36.8	86	177.9	54.4	46	235.3	71.9
7	06.7	02.0	67	64.1	19.6	27	121.5	37.1	87	178.8	54.7	47	236.2	72.2
8	07.7	02.3	68	65.0	19.9	28	122.4	37.4	88	179.8	55.0	48	237.2	72.5
9	08.6	02.6	69	66.0	20.2	29	123.4	37.7	89	180.7	55.3	49	238.1	72.8
10	09.6	02.9	70	66.9	20.5	30	124.3	38.0	90	181.7	55.6	50	239.1	73.1
11	10.5	03.2	71	67.9	20.8	131	125.3	38.3	191	182.7	55.8	251	240.0	73.4
12	11.5	03.5	72	68.9	21.1	32	126.2	38.6	92	183.6	56.1	52	241.0	73.7
13	12.4	03.8	73	69.8	21.3	33	127.2	38.9	93	184.6	56.4	53	241.9	74.0
14	13.4	04.1	74	70.8	21.6	34	128.1	39.2	94	185.5	56.7	54	242.9	74.3
15	14.3	04.4	75	71.7	21.9	35	129.1	39.5	95	186.5	57.0	55	243.9	74.6
16	15.3	04.7	76	72.7	22.2	36	130.1	39.8	96	187.4	57.3	56	244.8	74.8
17	16.3	05.0	77	73.6	22.5	37	131.0	40.1	97	188.4	57.6	57	245.8	75.1
18	17.2	05.3	78	74.6	22.8	38	132.0	40.3	98	189.3	57.9	58	246.7	75.4
19	18.2	05.6	79	75.5	23.1	39	132.9	40.6	99	190.3	58.2	59	247.7	75.7
20	19.1	05.8	80	76.5	23.4	40	133.9	40.9	200	191.3	58.5	60	248.6	76.0
21	20.1	06.1	81	77.5	23.7	141	134.8	41.2	201	192.2	58.8	261	249.6	76.3
22	21.0	06.4	82	78.4	24.0	42	135.8	41.5	02	193.2	59.1	62	250.6	76.6
23	22.0	06.7	83	79.4	24.3	43	136.8	41.8	03	194.1	59.4	63	251.5	76.9
24	23.0	07.0	84	80.3	24.6	44	137.7	42.1	04	195.1	59.6	64	252.5	77.2
25	23.9	07.3	85	81.3	24.9	45	138.7	42.4	05	196.0	59.9	65	253.4	77.5
26	24.9	07.6	86	82.2	25.1	46	139.6	42.7	06	197.0	60.2	66	254.4	77.8
27	25.8	07.9	87	83.2	25.4	47	140.6	43.0	07	198.0	60.5	67	255.3	78.1
28	26.8	08.2	88	84.2	25.7	48	141.5	43.3	08	198.9	60.8	68	256.3	78.4
29	27.7	08.5	89	85.1	26.0	49	142.5	43.6	09	199.9	61.1	69	257.2	78.6
30	28.7	08.8	90	86.1	26.3	50	143.4	43.9	10	200.8	61.4	70	258.2	78.9
31	29.6	09.1	91	87.0	26.6	151	144.4	44.1	211	201.8	61.7	271	259.2	79.2
32	30.6	09.4	92	88.0	26.9	52	145.4	44.4	12	202.7	62.0	72	260.1	79.5
33	31.6	09.6	93	88.9	27.2	53	146.3	44.7	13	203.7	62.3	73	261.1	79.8
34	32.5	09.9	94	89.9	27.5	54	147.3	45.0	14	204.6	62.6	74	262.0	80.1
35	33.5	10.2	95	90.8	27.8	55	148.2	45.3	15	205.6	62.9	75	263.0	80.4
36	34.4	10.5	96	91.8	28.1	56	149.2	45.6	16	206.6	63.2	76	263.9	80.7
37	35.4	10.8	97	92.8	28.4	57	150.1	45.9	17	207.5	63.4	77	264.9	81.0
38	36.3	11.1	98	93.7	28.7	58	151.1	46.2	18	208.5	63.7	78	265.9	81.3
39	37.3	11.4	99	94.7	28.9	59	152.1	46.5	19	209.4	64.0	79	266.8	81.6
40	38.3	11.7	100	95.6	29.2	60	153.0	46.8	20	210.4	64.3	80	267.8	81.9
41	39.2	12.0	101	96.6	29.5	161	154.0	47.1	221	211.3	64.6	281	268.7	82.2
42	40.2	12.3	02	97.5	29.8	62	154.9	47.4	22	212.3	64.9	82	269.7	82.4
43	41.1	12.6	03	98.5	30.1	63	155.9	47.7	23	213.3	65.2	83	270.6	82.7
44	42.1	12.9	04	99.5	30.4	64	156.8	47.9	24	214.2	65.5	84	271.6	83.0
45	43.0	13.2	05	100.4	30.7	65	157.8	48.2	25	215.2	65.8	85	272.5	83.3
46	44.0	13.4	06	101.4	31.0	66	158.7	48.5	26	216.1	66.1	86	273.5	83.6
47	44.9	13.7	07	102.3	31.3	67	159.7	48.8	27	217.1	66.4	87	274.5	83.9
48	45.9	14.0	08	103.3	31.6	68	160.7	49.1	28	218.0	66.7	88	275.4	84.2
49	46.9	14.3	09	104.2	31.9	69	161.6	49.4	29	219.0	67.0	89	276.4	84.5
50	47.8	14.6	10	105.2	32.2	70	162.6	49.7	30	220.0	67.2	90	277.3	84.8
51	48.8	14.9	111	106.1	32.5	171	163.5	50.0	231	220.9	67.5	291	278.3	85.1
52	49.7	15.2	12	107.1	32.7	72	164.5	50.3	32	221.9	67.8	92	279.2	85.4
53	50.7	15.5	13	108.1	33.0	73	165.4	50.6	33	222.8	68.1	93	280.2	85.7
54	51.6	15.8	14	109.0	33.3	74	166.4	50.9	34	223.8	68.4	94	281.2	86.0
55	52.6	16.1	15	110.0	33.6	75	167.4	51.2	35	224.7	68.7	95	282.1	86.2
56	53.6	16.4	16	110.9	33.9	76	168.3	51.5	36	225.7	69.0	96	283.1	86.5
57	54.5	16.7	17	111.9	34.2	77	169.3	51.7	37	226.6	69.3	97	284.0	86.8
58	55.5	17.0	18	112.8	34.5	78	170.2	52.0	38	227.6	69.6	98	285.0	87.1
59	56.4	17.2	19	113.8	34.8	79	171.2	52.3	39	228.6	69.9	99	285.9	87.4
60	57.4	17.5	20	114.8	35.1	80	172.1	52.6	40	229.5	70.2	300	286.9	87.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 18 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.3	61	58.0	18.9	121	115.1	37.4	181	172.1	55.9	241	229.2	74.5
2	01.9	00.6	62	59.0	19.2	22	116.0	37.7	82	173.1	56.2	42	230.2	74.8
3	02.9	00.9	63	59.9	19.5	23	117.0	38.0	83	174.0	56.6	43	231.1	75.1
4	03.8	01.2	64	60.9	19.8	24	117.9	38.3	84	175.0	56.9	44	232.1	75.4
5	04.8	01.5	65	61.8	20.1	25	118.9	38.6	85	175.9	57.2	45	233.0	75.7
6	05.7	01.9	66	62.8	20.4	26	119.8	38.9	86	176.9	57.5	46	234.0	76.0
7	06.7	02.2	67	63.7	20.7	27	120.8	39.2	87	177.8	57.8	47	234.9	76.3
8	07.6	02.5	68	64.7	21.0	28	121.7	39.6	88	178.8	58.1	48	235.9	76.6
9	08.6	02.8	69	65.6	21.3	29	122.7	39.9	89	179.7	58.4	49	236.8	76.9
10	09.5	03.1	70	66.6	21.6	30	123.6	40.2	90	180.7	58.7	50	237.8	77.3
11	10.5	03.4	71	67.5	21.9	131	124.6	40.5	191	181.7	59.0	251	238.7	77.6
12	11.4	03.7	72	68.5	22.2	32	125.5	40.8	92	182.6	59.3	52	239.7	77.9
13	12.4	04.0	73	69.4	22.6	33	126.5	41.1	93	183.6	59.6	53	240.6	78.2
14	13.3	04.3	74	70.4	22.9	34	127.4	41.4	94	184.5	59.9	54	241.6	78.5
15	14.3	04.6	75	71.3	23.2	35	128.4	41.7	95	185.5	60.3	55	242.5	78.8
16	15.2	04.9	76	72.3	23.5	36	129.3	42.0	96	186.4	60.6	56	243.5	79.1
17	16.2	05.3	77	73.2	23.8	37	130.3	42.3	97	187.4	60.9	57	244.4	79.4
18	17.1	05.6	78	74.2	24.1	38	131.2	42.6	98	188.3	61.2	58	245.4	79:7
19	18.1	05.9	79	75.1	24.4	39	132.2	43.0	99	189.3	61.5	59	246.3	80.0
20	19.0	06.2	80	76.1	24.7	40	133.1	43.3	200	190.2	61.8	60	247.3	80.3
21	20.0	06.5	81	77.0	25.0	141	134.1	43.6	201	191.2	62.1	261	248.2	80.7
22	20.9	06.8	82	78.0	25.3	42	135.1	43.9	02	192.1	62.4	62	249.2	81.0
23	21.9	07.1	83	78.9	25.6	43	136.0	44.2	03	193.1	62.7	63	250.1	81.3
24	22.8	07.4	84	79.9	26.0	44	137.0	44.5	04	194.0	63.0	64	251.1	81.6
25	23.8	07.7	85	80.8	26.3	45	137.9	44.8	05	195.0	63.3	65	252.0	81.9
26	24.7	08.0	86	81.8	26.6	46	138.9	45.1	06	195.9	63.7	66	253.0	82.2
27	25.7	08.3	87	82.7	26.9	47	139.8	45.4	07	196.9	64.0	67	253.9	82.5
28	26.6	08.7	88	83.7	27.2	48	140.8	45.7	08	197.8	64.3	68	254.9	82.8
29	27.6	09.0	89	84.6	27.5	49	141.7	46.0	09	198.8	64.6	69	255.8	83.1
30	28.5	09.3	90	85.6	27.8	50	142.7	46.4	10	199.7	64.9	70	256.8	83.4
31	29.5	09.6	91	86.5	28.1	151	143.6	46.7	211	200.7	65.2	271	257.7	83.7
32	30.4	09.9	92	87.5	28.4	52	144.6	47.0	12	201.6	65.5	72	258.7	84.1
33	31.4	10.2	93	88.4	28.7	53	145.5	47.3	13	202.6	65.8	73	259.6	84.4
34	32.3	10.5	94	89.4	29.0	54	146.5	47.6	14	203.5	66.1	74	260.6	84.7
35	33.3	10.8	95	90.4	29.4	55	147.4	47.9	15	204.5	66.4	75	261.5	85.0
36	34.2	11.1	96	91.3	29.7	56	148.4	48.2	16	205.4	66.7	76	262.5	85.3
37	35.2	11.4	97	92.3	30.0	57	149.3	48.5	17	206.4	67.1	77	263.4	85.6
38	36.1	11.7	98	93.2	30.3	58	150.3	48.8	18	207.3	67.4	78	264.4	85.9
39	37.1	12.1	99	94.2	30.6	59	151.2	49.1	19	208.3	67.7	79	265.3	86.2
40	38.0	12.4	100	95.1	30.9	60	152.2	49.4	20	209.2	68.0	80	266.3	86.5
41	39.0	12.7	101	96.1	31.2	161	153.1	49.8	221	210.2	68.3	281	267.2	86.8
42	39.9	13.0	02	97.0	31.5	62	154.1	50.1	22	211.1	68.6	82	268.2	87.1
43	40.9	13.3	03	98.0	31.8	63	155.0	50.4	23	212.1	68.9	83	269.1	87.5
44	41.8	13.6	04	98.9	32.1	64	156.0	50.7	24	213.0	69.2	84	270.1	87.8
45	42.8	13.9	05	99.9	32.4	65	156.9	51.0	25	214.0	69.5	85	271.1	88.1
46	43.7	14.2	06	100.8	32.8	66	157.9	51.3	26	214.9	69.8	86	272.0	88.4
47	44.7	14.5	07	101.8	33.1	67	158.8	51.6	27	215.9	70.1	87	273.0	88.7
48	45.7	14.8	08	102.7	33.4	68	159.8	51.9	28	216.8	70.5	88	273.9	89.0
49	46.6	15.1	09	103.7	33.7	69	160.7	52.2	29	217.8	70.8	89	274.9	89.3
50	47.6	15.5	10	104.6	34.0	70	161.7	52.5	30	218.7	71.1	90	275.8	89.6
51	48.5	15.8	111	105.6	34.3	171	162.6	52.8	231	219.7	71.4	291	276.8	89.9
52	49.5	16.1	12	106.5	34.6	72	163.6	53.2	32	220.6	71.7	92	277.7	90.2
53	50.4	16.4	13	107.5	34.9	73	164.5	53.5	33	221.6	72.0	93	278.7	90.5
54	51.4	16.7	14	108.4	35.2	74	165.5	53.8	34	222.5	72.3	94	279.6	90.9
55	52.3	17.0	15	109.4	35.5	75	166.4	54.1	35	223.5	72.6	95	280.6	91.2
56	53.3	17.3	16	110.3	35.8	76	167.4	54.4	36	224.4	72.9	96	281.5	91.5
57	54.2	17.6	17	111.3	36.2	77	168.3	54.7	37	225.4	73.2	97	282.5	91.8
58	55.2	17.9	18	112.2	36.5	78	169.3	55.0	38	226.4	73.5	98	283.4	92.1
59	56.1	18.2	19	113.2	36.8	79	170.2	55.3	39	227.3	73.9	99	284.4	92.4
60	57.1	18.5	20	114.1	37.1	80	171.2	55.6	40	228.3	74.2	300	285.3	92.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 72 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 19 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep
1	00.9	00.3	61	57.7	19.9	121	114.4	39.4	181	171.1	58.9	241	227.9	78.5
2	01.9	00.7	62	58.6	20.2	22	115.4	39.7	82	172.1	59.3	42	228.8	78.8
3	02.8	01.0	63	59.6	20.5	23	116.3	40.0	83	173.0	59.6	43	229.8	79.1
4	03.8	01.3	64	60.5	20.8	24	117.2	40.4	84	174.0	59.9	44	230.7	79.4
5	04.7	01.6	65	61.5	21.2	25	118.2	40.7	85	174.9	60.2	45	231.7	79.8
6	05.7	02.0	66	62.4	21.5	26	119.1	41.0	86	175.9	60.6	46	232.6	80.1
7	06.6	02.3	67	63.3	21.8	27	120.1	41.3	87	176.8	60.9	47	233.5	80.4
8	07.6	02.6	68	64.3	22.1	28	121.0	41.7	88	177.8	61.2	48	234.5	80.7
9	08.5	02.9	69	65.2	22.5	29	122.0	42.0	89	178.7	61.5	49	235.4	81.1
10	09.5	03.3	70	66.2	22.8	30	122.9	42.3	90	179.6	61.9	50	236.4	81.4
11	10.4	03.6	71	67.1	23.1	131	123.9	42.6	191	180.6	62.2	251	237.3	81.7
12	11.3	03.9	72	68.1	23.4	32	124.8	43.0	92	181.5	62.5	52	238.3	82.0
13	12.3	04.2	73	69.0	23.8	33	125.8	43.3	93	182.5	62.8	53	239.2	82.4
14	13.2	04.6	74	70.0	24.1	34	126.7	43.6	94	183.4	63.2	54	240.2	82.7
15	14.2	04.9	75	70.9	24.4	35	127.6	44.0	95	184.4	63.5	55	241.1	83.0
16	15.1	05.2	76	71.9	24.7	36	128.6	44.3	96	185.3	63.8	56	242.1	83.3
17	16.1	05.5	77	72.8	25.1	37	129.5	44.6	97	186.3	64.1	57	243.0	83.7
18	17.0	05.9	78	73.8	25.4	38	130.5	44.9	98	187.2	64.5	58	243.9	84.0
19	18.0	06.2	79	74.7	25.7	39	131.4	45.3	99	188.2	64.8	59	244.9	84.3
20	18.9	06.5	80	75.6	26.0	40	132.4	45.6	200	189.1	65.1	60	245.8	84.6
21	19.9	06.8	81	76.6	26.4	141	133.3	45.9	201	190.0	65.4	261	246.8	85.0
22	20.8	07.2	82	77.5	26.7	42	134.3	46.2	02	191.0	65.8	62	247.7	85.3
23	21.7	07.5	83	78.5	27.0	43	135.2	46.6	03	191.9	66.1	63	248.7	85.6
24	22.7	07.8	84	79.4	27.3	44	136.2	46.9	04	192.9	66.4	64	249.6	86.0
25	23.6	08.1	85	80.4	27.7	45	137.1	47.2	05	193.8	66.7	65	250.6	86.3
26	24.6	08.5	86	81.3	28.0	46	138.0	47.5	06	194.8	67.1	66	251.5	86.6
27	25.5	08.8	87	82.3	28.3	47	139.0	47.9	07	195.7	67.4	67	252.5	86.9
28	26.5	09.1	88	83.2	28.7	48	139.9	48.2	08	196.7	67.7	68	253.4	87.3
29	27.4	09.4	89	84.2	29.0	49	140.9	48.5	09	197.6	68.0	69	254.3	87.6
30	28.4	09.8	90	85.1	29.3	50	141.8	48.8	10	198.6	68.4	70	255.3	87.9
31	29.3	10.1	91	86.0	29.6	151	142.8	49.2	211	199.5	68.7	271	256.2	88.2
32	30.3	10.4	92	87.0	30.0	52	143.7	49.5	12	200.4	69.0	72	257.2	88.6
33	31.2	10.7	93	87.9	30.3	53	144.7	49.8	13	201.4	69.3	73	258.1	88.9
34	32.1	11.1	94	88.9	30.6	54	145.6	50.1	14	202.3	69.7	74	259.1	89.2
35	33.1	11.4	95	89.8	30.9	55	146.6	50.5	15	203.3	70.0	75	260.0	89.5
36	34.0	11.7	96	90.8	31.3	56	147.5	50.8	16	204.2	70.3	76	261.0	89.9
37	35.0	12.0	97	91.7	31.6	57	148.4	51.1	17	205.2	70.6	77	261.9	90.2
38	35.9	12.4	98	92.7	31.9	58	149.4	51.4	18	206.1	71.0	78	262.9	90.5
39	36.9	12.7	99	93.6	32.2	59	150.3	51.8	19	207.1	71.3	79	263.8	90.8
40	37.8	13.0	100	94.6	32.6	60	151.3	52.1	20	208.0	71.6	80	264.7	91.2
41	38.8	13.3	101	95.5	32.9	161	152.2	52.4	221	209.0	72.0	281	265.7	91.5
42	39.7	13.7	02	96.4	33.2	62	153.2	52.7	22	209.9	72.3	82	266.6	91.8
43	40.7	14.0	03	97.4	33.5	63	154.1	53.1	23	210.9	72.6	83	267.6	92.1
44	41.6	14.3	04	98.3	33.9	64	155.1	53.4	24	211.8	72.9	84	268.5	92.5
45	42.5	14.7	05	99.3	34.2	65	156.0	53.7	25	212.7	73.3	85	269.5	92.8
46	43.5	15.0	06	100.2	34.5	66	157.0	54.0	26	213.7	73.6	86	270.4	93.1
47	44.4	15.3	07	101.2	34.8	67	157.9	54.4	27	214.6	73.9	87	271.4	93.4
48	45.4	15.6	08	102.1	35.2	68	158.8	54.7	28	215.6	74.2	88	272.3	93.8
49	46.3	16.0	09	103.1	35.5	69	159.8	55.0	29	216.5	74.6	89	273.3	94.1
50	47.3	16.3	10	104.0	35.8	70	160.7	55.3	30	217.5	74.9	90	274.2	94.4
51	48.2	16.6	111	105.0	36.1	171	161.7	55.7	231	218.4	75.2	291	275.1	94.7
52	49.2	16.9	12	105.9	36.5	72	162.6	56.0	32	219.4	75.5	92	276.1	95.1
53	50.1	17.3	13	106.8	36.8	73	163.6	56.3	33	220.3	75.9	93	277.0	95.4
54	51.1	17.6	14	107.8	37.1	74	164.5	56.6	34	221.3	76.2	94	278.0	95.7
55	52.0	17.9	15	108.7	37.4	75	165.5	57.0	35	222.2	76.5	95	278.9	96.0
56	52.9	18.2	16	109.7	37.8	76	166.4	57.3	36	223.1	76.8	96	279.9	96.4
57	53.9	18.6	17	110.6	38.1	77	167.4	57.6	37	224.1	77.2	97	280.8	96.7
58	54.8	18.9	18	111.6	38.4	78	168.3	58.0	38	225.0	77.5	98	281.8	97.0
59	55.8	19.2	19	112.5	38.7	79	169.2	58.3	39	226.0	77.8	99	282.7	97.3
60	56.7	19.5	20	113.5	39.1	80	170.2	58.6	40	226.9	78.1	300	283.7	97.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 71 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 20 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.3	61	57.3	20.9	121	113.7	41.4	181	170.1	61.9	241	226.5	82.4
2	01.9	00.7	62	58.3	21.2	22	114.6	41.7	82	171.0	62.2	42	227.4	82.8
3	02.8	01.0	63	59.2	21.5	23	115.6	42.1	83	172.0	62.6	43	228.3	83.1
4	03.8	01.4	64	60.1	21.9	24	116.5	42.4	84	172.9	62.9	44	229.3	83.5
5	04.7	01.7	65	61.1	22.2	25	117.5	42.8	85	173.8	63.3	45	230.2	83.8
6	05.6	02.1	66	62.0	22.6	26	118.4	43.1	86	174.8	63.6	46	231.2	84.1
7	06.6	02.4	67	63.0	22.9	27	119.3	43.4	87	175.7	64.0	47	232.1	84.5
8	07.5	02.7	68	63.9	23.3	28	120.3	43.8	88	176.7	64.3	48	233.0	84.8
9	08.5	03.1	69	64.8	23.6	29	121.2	44.1	89	177.6	64.6	49	234.0	85.2
10	09.4	03.4	70	65.8	23.9	30	122.2	44.5	90	178.5	65.0	50	234.9	85.5
11	10.3	03.8	71	66.7	24.3	131	123.1	44.8	191	179.5	65.3	251	235.9	85.8
12	11.3	04.1	72	67.7	24.6	32	124.0	45.1	92	180.4	65.7	52	236.8	86.2
13	12.2	04.4	73	68.6	25.0	33	125.0	45.5	93	181.4	66.0	53	237.7	86.5
14	13.2	04.8	74	69.5	25.3	34	125.9	45.8	94	182.3	66.4	54	238.7	86.9
15	14.1	05.1	75	70.5	25.7	35	126.9	46.2	95	183.2	66.7	55	239.6	87.2
16	15.0	05.5	76	71.4	26.0	36	127.8	46.5	96	184.2	67.0	56	240.6	87.6
17	16.0	05.8	77	72.4	26.3	37	128.7	46.9	97	185.1	67.4	57	241.5	87.9
18	16.9	06.2	78	73.3	26.7	38	129.7	47.2	98	186.1	67.7	58	242.4	88.2
19	17.9	06.5	79	74.2	27.0	39	130.6	47.5	99	187.0	68.1	59	243.4	88.6
20	18.8	06.8	80	75.2	27.4	40	131.6	47.9	200	187.9	68.4	60	244.3	88.9
21	19.7	07.2	81	76.1	27.7	141	132.5	48.2	201	188.9	68.7	261	245.3	89.3
22	20.7	07.5	82	77.1	28.0	42	133.4	48.6	02	189.8	69.1	62	246.2	89.6
23	21.6	07.9	83	78.0	28.4	43	134.4	48.9	03	190.8	69.4	63	247.1	90.0
24	22.6	08.2	84	78.9	28.7	44	135.3	49.3	04	191.7	69.8	64	248.1	90.3
25	23.5	08.6	85	79.9	29.1	45	136.3	49.6	05	192.6	70.1	65	249.0	90.6
26	24.4	08.9	86	80.8	29.4	46	137.2	49.9	06	193.6	70.5	66	250.0	91.0
27	25.4	09.2	87	81.8	29.8	47	138.1	50.3	07	194.5	70.8	67	250.9	91.3
28	26.3	09.6	88	82.7	30.1	48	139.1	50.6	08	195.5	71.1	68	251.8	91.7
29	27.3	09.9	89	83.6	30.4	49	140.0	51.0	09	196.4	71.5	69	252.8	92.0
30	28.2	10.3	90	84.6	30.8	50	141.0	51.3	10	197.3	71.8	70	253.7	92.3
31	29.1	10.6	91	85.5	31.1	151	141.9	51.6	211	198.3	72.2	271	254.7	92.7
32	30.1	10.9	92	86.5	31.5	52	142.8	52.0	12	199.2	72.5	72	255.6	93.0
33	31.0	11.3	93	87.4	31.8	53	143.8	52.3	13	200.2	72.9	73	256.5	93.4
34	31.9	11.6	94	88.3	32.1	54	144.7	52.7	14	201.1	73.2	74	257.5	93.7
35	32.9	12.0	95	89.3	32.5	55	145.7	53.0	15	202.0	73.5	75	258.4	94.1
36	33.8	12.3	96	90.2	32.8	56	146.6	53.4	16	203.0	73.9	76	259.4	94.4
37	34.8	12.7	97	91.2	33.2	57	147.5	53.7	17	203.9	74.2	77	260.3	94.7
38	35.7	13.0	98	92.1	33.5	58	148.5	54.0	18	204.9	74.6	78	261.2	95.1
39	36.6	13.3	99	93.0	33.9	59	149.4	54.4	19	205.8	74.9	79	262.2	95.4
40	37.6	13.7	100	94.0	34.2	60	150.4	54.7	20	206.7	75.2	80	263.1	95.8
41	38.5	14.0	101	94.9	34.5	161	151.3	55.1	221	207.7	75.6	281	264.1	96.1
42	39.5	14.4	02	95.8	34.9	62	152.2	55.4	22	208.6	75.9	82	265.0	96.4
43	40.4	14.7	03	96.8	35.2	63	153.2	55.7	23	209.6	76.3	83	265.9	96.8
44	41.3	15.0	04	97.7	35.6	64	154.1	56.1	24	210.5	76.6	84	266.9	97.1
45	42.3	15.4	05	98.7	35.9	65	155.0	56.4	25	211.4	77.0	85	267.8	97.5
46	43.2	15.7	06	99.6	36.3	66	156.0	56.8	26	212.4	77.3	86	268.8	97.8
47	44.2	16.1	07	100.5	36.6	67	156.9	57.1	27	213.3	77.6	87	269.7	98.2
48	45.1	16.4	08	101.5	36.9	68	157.9	57.5	28	214.2	78.0	88	270.6	98.5
49	46.0	16.8	09	102.4	37.3	69	158.8	57.8	29	215.2	78.3	89	271.6	98.8
50	47.0	17.1	10	103.4	37.6	70	159.7	58.1	30	216.1	78.7	90	272.5	99.2
51	47.9	17.4	111	104.3	38.0	171	160.7	58.5	231	217.1	79.0	291	273.5	99.5
52	48.9	17.8	12	105.2	38.3	72	161.6	58.8	32	218.0	79.3	92	274.4	99.9
53	49.8	18.1	13	106.2	38.6	73	162.6	59.2	33	218.9	79.7	93	275.3	100.2
54	50.7	18.5	14	107.1	39.0	74	163.5	59.5	34	219.9	80.0	94	276.3	100.6
55	51.7	18.8	15	108.1	39.3	75	164.4	59.9	35	220.8	80.4	95	277.2	100.9
56	52.6	19.2	16	109.0	39.7	76	165.4	60.2	36	221.8	80.7	96	278.1	101.2
57	53.6	19.5	17	109.9	40.0	77	166.3	60.5	37	222.7	81.1	97	279.1	101.6
58	54.5	19.8	18	110.9	40.4	78	167.3	60.9	38	223.6	81.4	98	280.0	101.9
59	55.4	20.2	19	111.8	40.7	79	168.2	61.2	39	224.6	81.7	99	281.0	102.3
60	56.4	20.5	20	112.8	41.0	80	169.1	61.6	40	225.5	82.1	300	281.9	102.6
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 21 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	56.9	21.9	121	113.0	43.4	181	169.0	64.9	241	225.0	86.4
2	01.9	00.7	62	57.9	22.2	22	113.9	43.7	82	169.9	65.2	42	225.9	86.7
3	02.8	01.1	63	58.8	22.6	23	114.8	44.1	83	170.8	65.6	43	226.9	87.1
4	03.7	01.4	64	59.7	22.9	24	115.8	44.4	84	171.8	65.9	44	227.8	87.4
5	04.7	01.8	65	60.7	23.3	25	116.7	44.8	85	172.7	66.3	45	228.7	87.8
6	05.6	02.2	66	61.6	23.7	26	117.6	45.2	86	173.6	66.7	46	229.7	88.2
7	06.5	02.5	67	62.5	24.0	27	118.6	45.5	87	174.6	67.0	47	230.6	88.5
8	07.5	02.9	68	63.5	24.4	28	119.5	45.9	88	175.5	67.4	48	231.5	88.9
9	08.4	03.2	69	64.4	24.7	29	120.4	46.2	89	176.4	67.7	49	232.5	89.2
10	09.3	03.6	70	65.4	25.1	30	121.4	46.6	90	177.4	68.1	50	233.4	89.6
11	10.3	03.9	71	66.3	25.4	131	122.3	46.9	191	178.3	68.4	251	234.3	90.0
12	11.2	04.3	72	67.2	25.8	32	123.2	47.3	92	179.2	68.8	52	235.3	90.3
13	12.1	04.7	73	68.2	26.2	33	124.2	47.7	93	180.2	69.2	53	236 2	90.7
14	13.1	05.0	74	69.1	26.5	34	125.1	48.0	94	181.1	69.5	54	237.1	91.0
15	14.0	05.4	75	70.0	26.9	35	126.0	48.4	95	182.0	69.9	55	238.1	91.4
16	14.9	05.7	76	71.0	27.2	36	127.0	48.7	96	183.0	70.2	56	239.0	91.7
17	15.9	06.1	77	71.9	27.6	37	127.9	49.1	97	183.9	70.6	57	239.9	92.1
18	16.8	06.5	78	72.8	28.0	38	128.8	49.5	98	184.8	71.0	58	240.9	92.5
19	17.7	06.8	79	73.8	28.3	39	129.8	49.8	99	185.8	71.3	59	241.8	92.8
20	18.7	07.2	80	74.7	28.7	40	130.7	50.2	200	186.7	71.7	60	242.7	93.2
21	19.6	07.5	81	75.6	29.0	141	131.6	50.5	201	187.6	72.0	261	243.7	93.5
22	20.5	07.9	82	76.6	29.4	42	132.6	50.9	02	188.6	72.4	62	244.6	93.9
23	21.5	08.2	83	77.5	29.7	43	133.5	51.2	03	189.5	72.7	63	245.5	94.3
24	22.4	08.6	84	78.4	30.1	44	134.4	51.6	04	190.5	73.1	64	246.5	94.6
25	23.3	09.0	85	79.4	30.5	45	135.4	52.0	05	191.4	73.5	65	247.4	95.0
26	24.3	09.3	86	80.3	30.8	46	136.3	52.3	06	192.3	73.8	66	248.3	95.3
27	25.2	09.7	87	81.2	31.2	47	137.2	52.7	07	193.3	74.2	67	249.3	95.7
28	26.1	10.0	88	82.2	31.5	48	138.2	53.0	08	194.2	74.5	68	250.2	96.0
29	27.1	10.4	89	83.1	31.9	49	139.1	53.4	09	195.1	74.9	69	251.1	96.4
30	28.0	10.8	90	84.0	32.3	50	140.0	53.8	10	196.1	75.3	70	252.1	96.8
31	28.9	11.1	91	85.0	32.6	151	141.0	54.1	211	197.0	75.6	271	253.0	97.1
32	29.9	11.5	92	85.9	33.0	52	141.9	54.5	12	197.9	76.0	72	253.9	97.5
33	30.8	11.8	93	86.8	33.3	53	142.8	54.8	13	198.9	76.3	73	254.9	97.8
34	31.7	12.2	94	87.8	33.7	54	143.8	55.2	14	199.8	76.7	74	255.8	98.2
35	32.7	12.5	95	88.7	34.0	55	144.7	55.5	15	200.7	77.0	75	256.7	98.6
36	33.6	12.9	96	89.6	34.4	56	145.6	55.9	16	201.7	77.4	76	257.7	98.9
37	34.5	13.3	97	90.6	34.8	57	146.6	56.3	17	202.6	77.8	77	258.6	99.3
38	35.5	13.6	98	91.5	35.1	58	147.5	56.6	18	203.5	78.1	78	259.5	99.6
39	36.4	14.0	99	92.4	35.5	59	148.4	57.0	19	204.5	78.5	79	260.5	100.0
40	37.3	14.3	100	93.4	35.8	60	149.4	57.3	20	205.4	78.8	80	261.4	100.3
41	38.3	14.7	101	94.3	36.2	161	150.3	57.7	221	206.3	79.2	281	262.3	100.7
42	39.2	15.1	02	95.2	36.6	62	151.2	58.1	22	207.3	79.6	82	263.3	101.1
43	40.1	15.4	03	96.2	36.9	63	152.2	58.4	23	208.2	79.9	83	264.2	101.4
44	41.1	15.8	04	97.1	37.3	64	153.1	58.8	24	209.1	80.3	84	265.1	101.8
45	42.0	16.1	05	98.0	37.6	65	154.0	59.1	25	210.1	80.6	85	266.1	102.1
46	42.9	16.5	06	99.0	38.0	66	155.0	59.5	26	211.0	81.0	86	267.0	102.5
47	43.9	16.8	07	99.9	38.3	67	155.9	59.8	27	211.9	81.3	87	267.9	102.9
48	44.8	17.2	08	100.8	38.7	68	156.8	60.2	28	212.9	81.7	88	268.9	103.2
49	45.7	17.6	09	101.8	39.1	69	157.8	60.6	29	213.8	82.1	89	269.8	103.6
50	46.7	17.9	10	102.7	39.4	70	158.7	60.9	30	214.7	82.4	90	270.7	103.9
51	47.6	18.3	111	103.6	39.8	171	159.6	61.3	231	215.7	82.8	291	271.7	104.3
52	48.5	18.6	12	104.6	40.1	72	160.6	61.6	32	216.6	83.1	92	272.6	104.6
53	49.5	19.0	13	105.5	40.5	73	161.5	62.0	33	217.5	83.5	93	273.5	105.0
54	50.4	19.4	14	106.4	40.9	74	162.4	62.4	34	218.5	83.9	94	274.5	105 4
55	51.3	19.7	15	107.4	41.2	75	163.4	62.7	35	219.4	84.2	95	275.4	105.7
56	52.3	20.1	16	108.3	41.6	76	164.3	63.1	36	220.3	84.6	96	276.3	106.1
57	53.2	20.4	17	109.2	41.9	77	165.2	63.4	37	221.3	84.9	97	277.3	106.4
58	54.1	20.8	18	110.2	42.3	78	166.2	63.8	38	222.2	85.3	98	278.2	106.8
59	55.1	21.1	19	111.1	42.6	79	167.1	64.1	39	223.1	85.6	99	279.1	107.2
60	56.0	21.5	20	112.0	43.0	80	168.0	64.5	40	224.1	86.0	300	280.1	107.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 69 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 22 Degrees

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	56.6	22.9	121	112.2	45.3	181	167.8	67.8	241	223.5	90.3
2	01.9	00.7	62	57.5	23.2	22	113.1	45.7	82	168.7	68.2	42	224.4	90.7
3	02.8	01.1	63	58.4	23.6	23	114.0	46.1	83	169.7	68.6	43	225.3	91.0
4	03.7	01.5	64	59.3	24.0	24	115.0	46.5	84	170.6	68.9	44	226.2	91.4
5	04.6	01.9	65	60.3	24.3	25	115.9	46.8	85	171.5	69.3	45	227.2	91.8
6	05.6	02.2	66	61.2	24.7	26	116.8	47.2	86	172.5	69.7	46	228.1	92.2
7	06.5	02.6	67	62.1	25.1	27	117.8	47.6	87	173.4	70.1	47	229.0	92.5
8	07.4	03.0	68	63.0	25.5	28	118.7	47.9	88	174.3	70.4	48	229.9	92.9
9	08.3	03.4	69	64.0	25.8	29	119.6	48.3	89	175.2	70.8	49	230.9	93.3
10	09.3	03.7	70	64.9	26.2	30	120.5	48.7	90	176.2	71.2	50	231.8	93.7
11	10.2	04.1	71	65.8	26.6	131	121.5	49.1	191	177.1	71.5	251	232.7	94.0
12	11.1	04.5	72	66.8	27.0	32	122.4	49.4	92	178.0	71.9	52	233.7	94.4
13	12.1	04.9	73	67.7	27.3	33	123.3	49.8	93	178.9	72.3	53	234.6	94.8
14	13.0	05.2	74	68.6	27.7	34	124.2	50.2	94	179.9	72.7	54	235.5	95.2
15	13.9	05.6	75	69.5	28.1	35	125.2	50.6	95	180.8	73.0	55	236.4	95.5
16	14.8	06.0	76	70.5	28.5	36	126.1	50.9	96	181.7	73.4	56	237.4	95.9
17	15.8	06.4	77	71.4	28.8	37	127.0	51.3	97	182.7	73.8	57	238.3	96.3
18	16.7	06.7	78	72.3	29.2	38	128.0	51.7	98	183.6	74.2	58	239.2	96.6
19	17.6	07.1	79	73.2	29.6	39	128.9	52.1	99	184.5	74.5	59	240.1	97.0
20	18.5	07.5	80	74.2	30.0	40	129.8	52.4	200	185.4	74.9	60	241.1	97.4
21	19.5	07.9	81	75.1	30.3	141	130.7	52.8	201	186.4	75.3	261	242.0	97.8
22	20.4	08.2	82	76.0	30.7	42	131.7	53.2	02	187.3	75.7	62	242.9	98.1
23	21.3	08.6	83	77.0	31.1	43	132.6	53.6	03	188.2	76.0	63	243.8	98.5
24	22.3	09.0	84	77.9	31.5	44	133.5	53.9	04	189.1	76.4	64	244.8	98.9
25	23.2	09.4	85	78.8	31.8	45	134.4	54.3	05	190.1	76.8	65	245.7	99.3
26	24.1	09.7	86	79.7	32.2	46	135.4	54.7	06	191.0	77.2	66	246.6	99.6
27	25.0	10.1	87	80.7	32.6	47	136.3	55.1	07	191.9	77.5	67	247.6	100.0
28	26.0	10.5	88	81.6	33.0	48	137.2	55.4	08	192.9	77.9	68	248.5	100.4
29	26.9	10.9	89	82.5	33.3	49	138.2	55.8	09	193.8	78.3	69	249.4	100.8
30	27.8	11.2	90	83.4	33.7	50	139.1	56.2	10	194.7	78.7	70	250.3	101.1
31	28.7	11.6	91	84.4	34.1	151	140.0	56.6	211	195.6	79.0	271	251.3	101.5
32	29.7	12.0	92	85.3	34.5	52	140.9	56.9	12	196.6	79.4	72	252.2	101.9
33	30.6	12.4	93	86.2	34.8	53	141.9	57.3	13	197.5	79.8	73	253.1	102.3
34	31.5	12.7	94	87.2	35.2	54	142.8	57.7	14	198.4	80.2	74	254.0	102.6
35	32.5	13.1	95	88.1	35.6	55	143.7	58.1	15	199.3	80.5	75	255.0	103.0
36	33.4	13.5	96	89.0	36.0	56	144.6	58.4	16	200.3	80.9	76	255.9	103.4
37	34.3	13.9	97	89.9	36.3	57	145.6	58.8	17	201.2	81.3	77	256.8	103.8
38	35.2	14.2	98	90.9	36.7	58	146.5	59.2	18	202.1	81.7	78	257.8	104.1
39	36.2	14.6	99	91.8	37.1	59	147.4	59.6	19	203.1	82.0	79	258.7	104.5
40	37.1	15.0	100	92.7	37.5	60	148.3	59.9	20	204.0	82.4	80	259.6	104.9
41	38.0	15.4	101	93.6	37.8	161	149.3	60.3	221	204.9	82.8	281	260.5	105.3
42	38.9	15.7	02	94.6	38.2	62	150.2	60.7	22	205.8	83.2	82	261.5	105.6
43	39.9	16.1	03	95.5	38.6	63	151.1	61.1	23	206.8	83.5	83	262.4	106.0
44	40.8	16.5	04	96.4	39.0	64	152.1	61.4	24	207.7	83.9	84	263.3	106.4
45	41.7	16.9	05	97.4	39.3	65	153.0	61.8	25	208.6	84.3	85	264.2	106.8
46	42.7	17.2	06	98.3	39.7	66	153.9	62.2	26	209.5	84.7	86	265.2	107.1
47	43.6	17.6	07	99.2	40.1	67	154.8	62.6	27	210.5	85.0	87	266.1	107.5
48	44.5	18.0	08	100.1	40.5	68	155.8	62.9	28	211.4	85.4	88	267.0	107.9
49	45.4	18.4	09	101.1	40.8	69	156.7	63.3	29	212.3	85.8	89	268.0	108.3
50	46.4	18.7	10	102.0	41.2	70	157.6	63.7	30	213.3	86.2	90	268.9	108.6
51	47.3	19.1	111	102.9	41.6	171	158.5	64.1	231	214.2	86.5	291	269.8	109.0
52	48.2	19.5	12	103.8	42.0	72	159.5	64.4	32	215.1	86.9	92	270.7	109.4
53	49.1	19.9	13	104.8	42.3	73	160.4	64.8	33	216.0	87.3	93	271.7	109.8
54	50.1	20.2	14	105.7	42.7	74	161.3	65.2	34	217.0	87.7	94	272.6	110.1
55	51.0	20.6	15	106.6	43.1	75	162.3	65.6	35	217.9	88.0	95	273.5	110.5
56	51.9	21.0	16	107.6	43.5	76	163.2	65.9	36	218.8	88.4	96	274.4	110.9
57	52.8	21.4	17	108.5	43.8	77	164.1	66.3	37	219.7	88.8	97	275.4	111.3
58	53.8	21.7	18	109.4	44.2	78	165.0	66.7	38	220.7	89.2	98	276.3	111.6
59	54.7	22.1	19	110.3	44.6	79	166.0	67.1	39	221.6	89.5	99	277.2	112.0
60	55.6	22.5	20	111.3	45.0	80	166.9	67.4	40	222.5	89.9	300	278.2	112.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 23 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	56.2	23.8	121	111.4	47.3	181	166.6	70.7	241	221.8	94.2
2	01.8	00.8	62	57.1	24.2	22	112.3	47.7	82	167.5	71.1	42	222.8	94.6
3	02.8	01.2	63	58.0	24.6	23	113.2	48.1	83	168.5	71.5	43	223.7	94.9
4	03.7	01.6	64	58.9	25.0	24	114.1	48.5	84	169.4	71.9	44	224.6	95.3
5	04.6	02.0	65	59.8	25.4	25	115.1	48.8	85	170.3	72.3	45	225.5	95.7
6	05.5	02.3	66	60.8	25.8	26	116.0	49.2	86	171.2	72.7	46	226.4	96.1
7	06.4	02.7	67	61.7	26.2	27	116.9	49.6	87	172.1	73.1	47	227.4	96.5
8	07.4	03.1	68	62.6	26.6	28	117.8	50.0	88	173.1	73.5	48	228.3	96.9
9	08.3	03.5	69	63.5	27.0	29	118.7	50.4	89	174.0	73.8	49	229.2	97.3
10	09.2	03.9	70	64.4	27.4	30	119.7	50.8	90	174.9	74.2	50	230.1	97.7
11	10.1	04.3	71	65.4	27.7	131	120.6	51.2	191	175.8	74.6	251	231.0	98.1
12	11.0	04.7	72	66.3	28.1	32	121.5	51.6	92	176.7	75.0	52	232.0	98.5
13	12.0	05.1	73	67.2	28.5	33	122.4	52.0	93	177.7	75.4	53	232.9	98.9
14	12.9	05.5	74	68.1	28.9	34	123.3	52.4	94	178.6	75.8	54	233.8	99.2
15	13.8	05.9	75	69.0	29.3	35	124.3	52.7	95	179.5	76.2	55	234.7	99.6
16	14.7	06.3	76	70.0	29.7	36	125.2	53.1	96	180.4	76.6	56	235.6	100.0
17	15.6	06.6	77	70.9	30.1	37	126.1	53.5	97	181.3	77.0	57	236.6	100.4
18	16.6	07.0	78	71.8	30.5	38	127.0	53.9	98	182.3	77.4	58	237.5	100.8
19	17.5	07.4	79	72.7	30.9	39	128.0	54.3	99	183.2	77.8	59	238.4	101.2
20	18.4	07.8	80	73.6	31.3	40	128.9	54.7	200	184.1	78.1	60	239.3	101.6
21	19.3	08.2	81	74.6	31.6	141	129.8	55.1	201	185.0	78.5	261	240.3	102.0
22	20.3	08.6	82	75.5	32.0	42	130.7	55.5	02	185.9	78.9	62	241.2	102.4
23	21.2	09.0	83	76.4	32.4	43	131.6	55.9	03	186.9	79.3	63	242.1	102.8
24	22.1	09.4	84	77.3	32.8	44	132.6	56.3	04	187.8	79.7	64	243.0	103.2
25	23.0	09.8	85	78.2	33.2	45	133.5	56.7	05	188.7	80.1	65	243.9	103.5
26	23.9	10.2	86	79.2	33.6	46	134.4	57.0	06	189.6	80.5	66	244.9	103.9
27	24.9	10.5	87	80.1	34.0	47	135.3	57.4	07	190.5	80.9	67	245.8	104.3
28	25.8	10.9	88	81.0	34.4	48	136.2	57.8	08	191.5	81.3	68	246.7	104.7
29	26.7	11.3	89	81.9	34.8	49	137.2	58.2	09	192.4	81.7	69	247.6	105.1
30	27.6	11.7	90	82.8	35.2	50	138.1	58.6	10	193.3	82.1	70	248.5	105.5
31	28.5	12.1	91	83.8	35.6	151	139.0	59.0	211	194.2	82.4	271	249.5	105.9
32	29.5	12.5	92	84.7	35.9	52	139.9	59.4	12	195.1	82.8	72	250.4	106.3
33	30.4	12.9	93	85.6	36.3	53	140.8	59.8	13	196.1	83.2	73	251.3	106.7
34	31.3	13.3	94	86.5	36.7	54	141.8	60.2	14	197.0	83.6	74	252.2	107.1
35	32.2	13.7	95	87.4	37.1	55	142.7	60.6	15	197.9	84.0	75	253.1	107.5
36	33.1	14.1	96	88.4	37.5	56	143.6	61.0	16	198.8	84.4	76	254.1	107.8
37	34.1	14.5	97	89.3	37.9	57	144.5	61.3	17	199.7	84.8	77	255.0	108.2
38	35.0	14.8	98	90.2	38.3	58	145.4	61.7	18	200.7	85.2	78	255.9	108.6
39	35.9	15.2	99	91.1	38.7	59	146.4	62.1	19	201.6	85.6	79	256.8	109.0
40	36.8	15.6	100	92.1	39.1	60	147.3	62.5	20	202.5	86.0	80	257.7	109.4
41	37.7	16.0	101	93.0	39.5	161	148.2	62.9	221	203.4	86.4	281	258.7	109.8
42	38.7	16.4	02	93.9	39.9	62	149.1	63.3	22	204.4	86.7	82	259.6	110.2
43	39.6	16.8	03	94.8	40.2	63	150.0	63.7	23	205.3	87.1	83	260.5	110.6
44	40.5	17.2	04	95.7	40.6	64	151.0	64.1	24	206.2	87.5	84	261.4	111.0
45	41.4	17.6	05	96.7	41.0	65	151.9	64.5	25	207.1	87.9	85	262.3	111.4
46	42.3	18.0	06	97.6	41.4	66	152.8	64.9	26	208.0	88.3	86	263.3	111.7
47	43.3	18.4	07	98.5	41.8	67	153.7	65.3	27	209.0	88.7	87	264.2	112.1
48	44.2	18.8	08	99.4	42.2	68	154.6	65.6	28	209.9	89.1	88	265.1	112.5
49	45.1	19.1	09	100.3	42.6	69	155.6	66.0	29	210.8	89.5	89	266.0	112.9
50	46.0	19.5	10	101.3	43.0	70	156.5	66.4	30	211.7	89.9	90	266.9	113.3
51	46.9	19.9	111	102.2	43.4	171	157.4	66.8	231	212.6	90.3	291	267.9	113.7
52	47.9	20.3	12	103.1	43.8	72	158.3	67.2	32	213.6	90.6	92	268.8	114.1
53	48.8	20.7	13	104.0	44.2	73	159.2	67.6	33	214.5	91.0	93	269.7	114.5
54	49.7	21.1	14	104.9	44.5	74	160.2	68.0	34	215.4	91.4	94	270.6	114.9
55	50.6	21.5	15	105.9	44.9	75	161.1	68.4	35	216.3	91.8	95	271.5	115.3
56	51.5	21.9	16	106.8	45.3	76	162.0	68.8	36	217.2	92.2	96	272.5	115.7
57	52.5	22.3	17	107.7	45.7	77	162.9	69.2	37	218.2	92.6	97	273.4	116.0
58	53.4	22.7	18	108.6	46.1	78	163.8	69.6	38	219.1	93.0	98	274.3	116.4
59	54.3	23.1	19	109.5	46.5	79	164.8	69.9	39	220.0	93.4	99	275.2	116.8
60	55.2	23.4	20	110.5	46.9	80	165.7	70.3	40	220.9	93.8	300	276.2	117.2
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 67 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 24 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	55.7	24.8	121	110.5	49.2	181	165.4	73.6	241	220.2	98.0
2	01.8	00.8	62	56.6	25.2	22	111.5	49.6	82	166.3	74.0	42	221.1	98.4
3	02.7	01.2	63	57.6	25.6	23	112.4	50.0	83	167.2	74.4	43	222.0	98.8
4	03.7	01.6	64	58.5	26.0	24	113.3	50.4	84	168.1	74.8	44	222.9	99.2
5	04.6	02.0	65	59.4	26.4	25	114.2	50.8	85	169.0	75.2	45	223.8	99.7
6	05.5	02.4	66	60.3	26.8	26	115.1	51.2	86	169.9	75.7	46	224.7	100.1
7	06.4	02.8	67	61.2	27.3	27	116.0	51.7	87	170.8	76.1	47	225.6	100.5
8	07.3	03.3	68	62.1	27.7	28	116.9	52.1	88	171.7	76.5	48	226.6	100.9
9	08.2	03.7	69	63.0	28.1	29	117.8	52.5	89	172.7	76.9	49	227.5	101.3
10	09.1	04.1	70	63.9	28.5	30	118.8	52.9	90	173.6	77.3	50	228.4	101.7
11	10.0	04.5	71	64.9	28.9	131	119.7	53.3	191	174.5	77.7	251	229.3	102.1
12	11.0	04.9	72	65.8	29.3	32	120.6	53.7	92	175.4	78.1	52	230.2	102.5
13	11.9	05.3	73	66.7	29.7	33	121.5	54.1	93	176.3	78.5	53	231.1	102.9
14	12.8	05.7	74	67.6	30.1	34	122.4	54.5	94	177.2	78.9	54	232.0	103.3
15	13.7	06.1	75	68.5	30.5	35	123.3	54.9	95	178.1	79.3	55	233.0	103.7
16	14.6	06.5	76	69.4	30.9	36	124.2	55.3	96	179.1	79.7	56	233.9	104.1
17	15.5	06.9	77	70.3	31.3	37	125.2	55.7	97	180.0	80.1	57	234.8	104.5
18	16.4	07.3	78	71.3	31.7	38	126.1	56.1	98	180.9	80.5	58	235.7	104.9
19	17.4	07.7	79	72.2	32.1	39	127.0	56.5	99	181.8	80.9	59	236.6	105.3
20	18.3	08.1	80	73.1	32.5	40	127.9	56.9	200	182.7	81.3	60	237.5	105.8
21	19.2	08.5	81	74.0	32.9	141	128.8	57.3	201	183.6	81.8	261	238.4	106.2
22	20.1	08.9	82	74.9	33.4	42	129.7	57.8	02	184.5	82.2	62	239.3	106.6
23	21.0	09.4	83	75.8	33.8	43	130.6	58.2	03	185.4	82.6	63	240.3	107.0
24	21.9	09.8	84	76.7	34.2	44	131.6	58.6	04	186.4	83.0	64	241.2	107.4
25	22.8	10.2	85	77.7	34.6	45	132.5	59.0	05	187.3	83.4	65	242.1	107.8
26	23.8	10.6	86	78.6	35.0	46	133.4	59.4	06	188.2	83.8	66	243.0	108.2
27	24.7	11.0	87	79.5	35.4	47	134.3	59.8	07	189.1	84.2	67	243.9	108.6
28	25.6	11.4	88	80.4	35.8	48	135.2	60.2	08	190.0	84.6	68	244.8	109.0
29	26.5	11.8	89	81.3	36.2	49	136.1	60.6	09	190.9	85.0	69	245.7	109.4
30	27.4	12.2	90	82.2	36.6	50	137.0	61.0	10	191.8	85.4	70	246.7	109.8
31	28.3	12.6	91	83.1	37.0	151	137.9	61.4	211	192.8	85.8	271	247.6	110.2
32	29.2	13.0	92	84.0	37.4	52	138.9	61.8	12	193.7	86.2	72	248.5	110.6
33	30.1	13.4	93	85.0	37.8	53	139.8	62.2	13	194.6	86.6	73	249.4	111.0
34	31.1	13.8	94	85.9	38.2	54	140.7	62.6	14	195.5	87.0	74	250.3	111.4
35	32.0	14.2	95	86.8	38.6	55	141.6	63.0	15	196.4	87.4	75	251.2	111.9
36	32.9	14.6	96	87.7	39.0	56	142.5	63.5	16	197.3	87.9	76	252.1	112.3
37	33.8	15.0	97	88.6	39.5	57	143.4	63.9	17	198.2	88.3	77	253.1	112.7
38	34.7	15.5	98	89.5	39.9	58	144.3	64.3	18	199.2	88.7	78	254.0	113.1
39	35.6	15.9	99	90.4	40.3	59	145.3	64.7	19	200.1	89.1	79	254.9	113.5
40	36.5	16.3	100	91.4	40.7	60	146.2	65.1	20	201.0	89.5	80	255.8	113.9
41	37.5	16.7	101	92.3	41.1	161	147.1	65.5	221	201.9	89.9	281	256.7	114.3
42	38.4	17.1	02	93.2	41.5	62	148.0	65.9	22	202.8	90.3	82	257.6	114.7
43	39.3	17.5	03	94.1	41.9	63	148.9	66.3	23	203.7	90.7	83	258.5	115.1
44	40.2	17.9	04	95.0	42.3	64	149.8	66.7	24	204.6	91.1	84	259.4	115.5
45	41.1	18.3	05	95.9	42.7	65	150.7	67.1	25	205.5	91.5	85	260.4	115.9
46	42.0	18.7	06	96.8	43.1	66	151.6	67.5	26	206.5	91.9	86	261.3	116.3
47	42.9	19.1	07	97.7	43.5	67	152.6	67.9	27	207.4	92.3	87	262.2	116.7
48	43.9	19.5	08	98.7	43.9	68	153.5	68.3	28	208.3	92.7	88	263.1	117.1
49	44.8	19.9	09	99.6	44.3	69	154.4	68.7	29	209.2	93.1	89	264.0	117.5
50	45.7	20.3	10	100.5	44.7	70	155.3	69.1	30	210.1	93.5	90	264.9	118.0
51	46.6	20.7	111	101.4	45.1	171	156.2	69.6	231	211.0	94.0	291	265.8	118.4
52	47.5	21.2	12	102.3	45.6	72	157.1	70.0	32	211.9	94.4	92	266.8	118.8
53	48.4	21.6	13	103.2	46.0	73	158.0	70.4	33	212.9	94.8	93	267.7	119.2
54	49.3	22.0	14	104.1	46.4	74	159.0	70.8	34	213.8	95.2	94	268.6	119.6
55	50.2	22.4	15	105.1	46.8	75	159.9	71.2	35	214.7	95.6	95	269.5	120.0
56	51.2	22.8	16	106.0	47.2	76	160.8	71.6	36	215.6	96.0	96	270.4	120.4
57	52.1	23.2	17	106.9	47.6	77	161.7	72.0	37	216.5	96.4	97	271.3	120.8
58	53.0	23.6	18	107.8	48.0	78	162.6	72.4	38	217.4	96.8	98	272.2	121.2
59	53.9	24.0	19	108.7	48.4	79	163.5	72.8	39	218.3	97.2	99	273.2	121.6
60	54.8	24.4	20	109.6	48.8	80	164.4	73.2	40	219.3	97.6	300	274.1	122.0
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 66 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 25 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	55.3	25.8	121	109.7	51.1	181	164.0	76.5	241	218.4	101.9
2	01.8	00.8	62	56.2	26.2	22	110.6	51.6	82	164.9	76.9	42	219.3	102.3
3	02.7	01.3	63	57.1	26.6	23	111.5	52.0	83	165.9	77.3	43	220.2	102.7
4	03.6	01.7	64	58.0	27.0	24	112.4	52.4	84	166.8	77.8	44	221.1	103.1
5	04.5	02.1	65	58.9	27.5	25	113.3	52.8	85	167.7	78.2	45	222.0	103.5
6	05.4	02.5	66	59.8	27.9	26	114.2	53.2	86	168.6	78.6	46	223.0	104.0
7	06.3	03.0	67	60.7	28.3	27	115.1	53.7	87	169.5	79.0	47	223.9	104.4
8	07.3	03.4	68	61.6	28.7	28	116.0	54.1	88	170.4	79.5	48	224.8	104.8
9	08.2	03.8	69	62.5	29.2	29	116.9	54.5	89	171.3	79.9	49	225.7	105.2
10	09.1	04.2	70	63.4	29.6	30	117.8	54.9	90	172.2	80.3	50	226.6	105.7
11	10.0	04.6	71	64.3	30.0	131	118.7	55.4	191	173.1	80.7	251	227.5	106.1
12	10.9	05.1	72	65.3	30.4	32	119.6	55.8	92	174.0	81.1	52	228.4	106.5
13	11.8	05.5	73	66.2	30.9	33	120.5	56.2	93	174.9	81.6	53	229.3	106.9
14	12.7	05.9	74	67.1	31.3	34	121.4	56.6	94	175.8	82.0	54	230.2	107.3
15	13.6	06.3	75	68.0	31.7	35	122.4	57.1	95	176.7	82.4	55	231.1	107.8
16	14.5	06.8	76	68.9	32.1	36	123.3	57.5	96	177.6	82.8	56	232.0	108.2
17	15.4	07.2	77	69.8	32.5	37	124.2	57.9	97	178.5	83.3	57	232.9	108.6
18	16.3	07.6	78	70.7	33.0	38	125.1	58.3	98	179.4	83.7	58	233.8	109.0
19	17.2	08.0	79	71.6	33.4	39	126.0	58.7	99	180.4	84.1	59	234.7	109.5
20	18.1	08.5	80	72.5	33.8	40	126.9	59.2	200	181.3	84.5	60	235.6	109.9
21	19.0	08.9	81	73.4	34.2	141	127.8	59.6	201	182.2	84.9	261	236.5	110.3
22	19.9	09.3	82	74.3	34.7	42	128.7	60.0	02	183.1	85.4	62	237.5	110.7
23	20.8	09.7	83	75.2	35.1	43	129.6	60.4	03	184.0	85.8	63	238.4	111.1
24	21.8	10.1	84	76.1	35.5	44	130.5	60.9	04	184.9	86.2	64	239.3	111.6
25	22.7	10.6	85	77.0	35.9	45	131.4	61.3	05	185.8	86.6	65	240.2	112.0
26	23.6	11.0	86	77.9	36.3	46	132.3	61.7	06	186.7	87.1	66	241.1	112.4
27	24.5	11.4	87	78.8	36.8	47	133.2	62.1	07	187.6	87.5	67	242.0	112.8
28	25.4	11.8	88	79.8	37.2	48	134.1	62.5	08	188.5	87.9	68	242.9	113.3
29	26.3	12.3	89	80.7	37.6	49	135.0	63.0	09	189.4	88.3	69	243.8	113.7
30	27.2	12.7	90	81.6	38.0	50	135.9	63.4	10	190.3	88.7	70	244.[illegible]	114.1
31	28.1	13.1	91	82.5	38.5	151	136.9	63.8	211	191.2	89.2	271	245.6	114.5
32	29.0	13.5	92	83.4	38.9	52	137.8	64.2	12	192.1	89.6	72	246.5	115.0
33	29.9	13.9	93	84.3	39.3	53	138.7	64.7	13	193.0	90.0	73	247.4	115.4
34	30.8	14.4	94	85.2	39.7	54	139.6	65.1	14	193.9	90.4	74	248.3	115.8
35	31.7	14.8	95	86.1	40.1	55	140.5	65.5	15	194.9	90.9	75	249.2	116.2
36	32.6	15.2	96	87.0	40.6	56	141.4	65.9	16	195.8	91.3	76	250.1	116.6
37	33.5	15.6	97	87.9	41.0	57	142.3	66.4	17	196.7	91.7	77	251.0	117.1
38	34.4	16.1	98	88.8	41.4	58	143.2	66.8	18	197.6	92.1	78	252.0	117.5
39	35.3	16.5	99	89.7	41.8	59	144.1	67.2	19	198.5	92.6	79	252.9	117.9
40	36.3	16.9	100	90.6	42.3	60	145.0	67.6	20	199.4	93.0	80	253.8	118.3
41	37.2	17.3	101	91.5	42.7	161	145.9	68.0	221	200.3	93.4	281	254.7	118.8
42	38.1	17.7	02	92.4	43.1	62	146.8	68.5	22	201.2	93.8	82	255.6	119.2
43	39.0	18.2	03	93.3	43.5	63	147.7	68.9	23	202.1	94.2	83	256.5	119.6
44	39.9	18.6	04	94.3	44.0	64	148.6	69.3	24	203.0	94.7	84	257.4	120.0
45	40.8	19.0	05	95.2	44.4	65	149.5	69.7	25	203.9	95.1	85	258.3	120.4
46	41.7	19.4	06	96.1	44.8	66	150.4	70.2	26	204.8	95.5	86	259.2	120.9
47	42.6	19.9	07	97.0	45.2	67	151.4	70.6	27	205.7	95.9	87	260.1	121.3
48	43.5	20.3	08	97.9	45.6	68	152.3	71.0	28	206.6	96.4	88	261.0	121.7
49	44.4	20.7	09	98.8	46.1	69	153.2	71.4	29	207.5	96.8	89	261.9	122.1
50	45.3	21.1	10	99.7	46.5	70	154.1	71.8	30	208.5	97.2	90	262.8	122.6
51	46.2	21.6	111	100.6	46.9	171	155.0	72.3	231	209.4	97.6	291	263.7	123.0
52	47.1	22.0	12	101.5	47.3	72	155.9	72.7	32	210.3	98.0	92	264.6	123.4
53	48.0	22.4	13	102.4	47.8	73	156.8	73.1	33	211.2	98.5	93	265.5	123.8
54	48.9	22.8	14	103.3	48.2	74	157.7	73.5	34	212.1	98.9	94	266.5	124.2
55	49.8	23.2	15	104.2	48.6	75	158.6	74.0	35	213.0	99.3	95	267.4	124.7
56	50.8	23.7	16	105.1	49.0	76	159.5	74.4	36	213.9	99.7	96	268.3	125.1
57	51.7	24.1	17	106.0	49.4	77	160.4	74.8	37	214.8	100.2	97	269.2	125.5
58	52.6	24.5	18	106.9	49.9	78	161.3	75.2	38	215.7	100.6	98	270.1	125.9
59	53.5	24.9	19	107.9	50.3	79	162.2	75.6	39	216.6	101.0	99	271.0	126.4
60	54.4	25.4	20	108.8	50.7	80	163.1	76.1	40	217.5	101.4	300	271.9	126.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 65 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 26 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	54.8	26.7	121	108.8	53.0	181	162.7	79.3	241	216.6	105.6
2	01.8	00.9	62	55.7	27.2	22	109.7	53.5	82	163.6	79.8	42	217.5	106.1
3	02.7	01.3	63	56.6	27.6	23	110.6	53.9	83	164.5	80.2	43	218.4	106.5
4	03.6	01.8	64	57.5	28.1	24	111.5	54.4	84	165.4	80.7	44	219.3	107.0
5	04.5	02.2	65	58.4	28.5	25	112.3	54.8	85	166.3	81.1	45	220.2	107.4
6	05.4	02 6	66	59.3	28.9	26	113.2	55.2	86	167.2	81.5	46	221.1	107.8
7	06.3	03.1	67	60.2	29.4	27	114.1	55.7	87	168.1	82.0	47	222.0	108.3
8	07.2	03.5	68	61.1	29.8	28	115.0	56.1	88	169.0	82.4	48	222.9	108.7
9	08.1	03.9	69	62.0	30.2	29	115.9	56.5	89	169.9	82.9	49	223.8	109.2
10	09.0	04.4	70	62.9	30.7	30	116.8	57.0	90	170.8	83.3	50	224.7	109.6
11	09.9	04.8	71	63.8	31.1	131	117.7	57.4	191	171.7	83.7	251	225.6	110.0
12	10.8	05.3	72	64.7	31.6	32	118.6	57.9	92	172.6	84.2	52	226.5	110.5
13	11.7	05.7	73	65.6	32.0	33	119.5	58.3	93	173.5	84.6	53	227.4	110.9
14	12.6	06.1	74	66.5	32.4	34	120.4	58.7	94	174.4	85.0	54	228.3	111.3
15	13.5	06.6	75	67.4	32.9	35	121.3	59.2	95	175.3	85.5	55	229.2	111.8
16	14.4	07.0	76	68.3	33.3	36	122.2	59.6	96	176.2	85.9	56	230.1	112.2
17	15.3	07.5	77	69.2	33.8	37	123.1	60.1	97	177.1	86.4	57	231.0	112.7
18	16.2	07.9	78	70.1	34.2	38	124.0	60.5	98	178.0	86.8	58	231.9	113.1
19	17.1	08.3	79	71.0	34.6	39	124.9	60.9	99	178.9	87.2	59	232.8	113.5
20	18.0	08.8	80	71.9	35.1	40	125.8	61.4	200	179.8	87.7	60	233.7	114.0
21	18.9	09.2	81	72.8	35.5	141	126.7	61.8	201	180.7	88.1	261	234.6	114.4
22	19.8	09.6	82	73.7	35.9	42	127.6	62.2	02	181.6	88.6	62	235.5	114.9
23	20.7	10.1	83	74.6	36.4	43	128.5	62.7	03	182.5	89.0	63	236.4	115 3
24	21.6	10.5	84	75.5	36.8	44	129.4	63.1	04	183.4	89.4	64	237.3	115.7
25	22.5	11.0	85	76.4	37.3	45	130.3	63.6	05	184.3	89.9	65	238.2	116.2
26	23.4	11.4	86	77.3	37.7	46	131.2	64.0	06	185.2	90.3	66	239.1	116.6
27	24.3	11.8	87	78.2	38.1	47	132.1	64.4	07	186.1	90.7	67	240.0	117.0
28	25.2	12.3	88	79.1	38.6	48	133.0	64.9	08	186.9	91.2	68	240.9	117.5
29	26.1	12.7	89	80.0	39.0	49	133.9	65.3	09	187.8	91.6	69	241.8	117.9
30	27.0	13.2	90	80.9	39.5	50	134.8	65.8	10	188.7	92.1	70	242.7	118.4
31	27.9	13.6	91	81.8	39.9	151	135.7	66.2	211	189.6	92.5	271	243.6	118.8
32	28.8	14.0	92	82.7	40.3	52	136.6	66.6	12	190.5	92.9	72	244.5	119.2
33	29.7	14.5	93	83.6	40.8	53	137.5	67.1	13	191.4	93.4	73	245.4	119.7
34	30.6	14.9	94	84.5	41.2	54	138.4	67.5	14	192.3	93.8	74	246.3	120.1
35	31.5	15.3	95	85.4	41.6	55	139.3	67.9	15	193.2	94.2	75	247.2	120.6
36	32.4	15.8	96	86.3	42.1	56	140.2	68.4	16	194.1	94.7	76	248.1	121.0
37	33.3	16.2	97	87.2	42.5	57	141.1	68.8	17	195.0	95.1	77	249.0	121.4
38	34.2	16.7	98	88.1	43.0	58	142.0	69.3	18	195.9	95.6	78	249.9	121.9
39	35.1	17.1	99	89.0	43.4	59	142.9	69.7	19	196.8	96.0	79	250.8	122.3
40	36.0	17.5	100	89.9	43.8	60	143.8	70.1	20	197.7	96.4	80	251.7	122.7
41	36.9	18.0	101	90.8	44.3	161	144.7	70.6	221	198.6	96.9	281	252.6	123.2
42	37.7	18.4	02	91.7	44.7	62	145.6	71.0	22	199.5	97.3	82	253.5	123.6
43	38.6	18.8	03	92.6	45.2	63	146 5	71.5	23	200.4	97.8	83	254.4	124.1
44	39.5	19.3	04	93.5	45.6	64	147.4	71.9	24	201.3	98.2	84	255.3	124.5
45	40.4	19.7	05	94.4	46.0	65	148.3	72.3	25	202.2	98.6	85	256.2	124.9
46	41.3	20.2	06	95.3	46.5	66	149.2	72.8	26	203.1	99.1	86	257.1	125.4
47	42.2	20.6	07	96.2	46.9	67	150.1	73.2	27	204.0	99.5	87	258.0	125.8
48	43.1	21.0	08	97.1	47.3	68	151.0	73.6	28	204.9	99.9	88	258.9	126.3
49	44.0	21.5	09	98.0	47.8	69	151.9	74.1	29	205.8	100.4	89	259.8	126.7
50	44.9	21.9	10	98.9	48.2	70	152.8	74.5	30	206.7	100.8	90	260.7	127.1
51	45.8	22.4	111	99.8	48.7	171	153.7	75.0	231	207.6	101.3	291	261.5	127.6
52	46.7	22.8	12	100.7	49.1	72	154.6	75.4	32	208.5	101.7	92	262.4	128.0
53	47.6	23.2	13	101.6	49.5	73	155.5	75.8	33	209.4	102.1	93	263 3	128.4
54	48.5	23.7	14	102.5	50.0	74	156.4	76.3	34	210.3	102.6	94	264.2	128.9
55	49.4	24.1	15	103.4	50.4	75	157.3	76.7	35	211.2	103.0	95	265.1	129.3
56	50.3	24.5	16	104.3	50.9	76	158.2	77.2	36	212.1	103.5	96	266.0	129.8
57	51.2	25.0	17	105.2	51.3	77	159.1	77.6	37	213.0	103.9	97	266.9	130.2
58	52.1	25.4	18	106.1	51.7	78	160.0	78.0	38	213.9	104.3	98	267.8	130.6
59	53.0	25 9	19	107.0	52.2	79	160.9	78.5	39	214.8	104.8	99	268.7	131.1
60	53.9	26 3	20	107.9	52.6	80	161.8	78.9	40	215.7	105.2	300	269.6	131.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II

Difference of Latitude and Departure for 27 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.5	61	54.4	27.7	121	107.8	54.9	181	161.3	82.2	241	214.7	109.4
2	01.8	00.9	62	55.2	28.1	22	108.7	55.4	82	162.2	82.6	42	215.6	109.9
3	02.7	01.4	63	56.1	28.6	23	109.6	55.8	83	163.1	83.1	43	216.5	110.3
4	03.6	01.8	64	57.0	29.1	24	110.5	56.3	84	163.9	83.5	44	217.4	110.8
5	04.5	02.3	65	57.9	29.5	25	111.4	56.7	85	164.8	84.0	45	218.3	111.2
6	05.3	02.7	66	58.8	30.0	26	112.3	57.2	86	165.7	84.4	46	219.2	111.7
7	06.2	03.2	67	59.7	30.4	27	113.2	57.7	87	166.6	84.9	47	220.1	112.1
8	07.1	03.6	68	60.6	30.9	28	114.0	58.1	88	167.5	85.4	48	221.0	112.6
9	08.0	04.1	69	61.5	31.3	29	114.9	58.6	89	168.4	85.8	49	221.9	113.0
10	08.9	04.5	70	62.4	31.8	30	115.8	59.0	90	169.3	86.3	50	222.8	113.5
11	09.8	05.0	71	63.3	32.2	131	116.7	59.5	191	170.2	86.7	251	223.6	114.0
12	10.7	05.4	72	64.2	32.7	32	117.6	59.9	92	171.1	87.2	52	224.5	114.4
13	11.6	05.9	73	65.0	33.1	33	118.5	60.4	93	172.0	87.6	53	225.4	114.9
14	12.5	06.4	74	65.9	33.6	34	119.4	60.8	94	172.9	88.1	54	226.3	115.3
15	13.4	06.8	75	66.8	34.0	35	120.3	61.3	95	173.7	88.5	55	227.2	115.8
16	14.3	07.3	76	67.7	34.5	36	121.2	61.7	96	174.6	89.0	56	228.1	116.2
17	15.1	07.7	77	68.6	35.0	37	122.1	62.2	97	175.5	89.4	57	229.0	116.7
18	16.0	08.2	78	69.5	35.4	38	123.0	62.7	98	176.4	89.9	58	229.9	117.1
19	16.9	08.6	79	70.4	35.9	39	123.8	63.1	99	177.3	90.3	59	230.8	117.6
20	17.8	09.1	80	71.3	36.3	40	124.7	63.6	200	178.2	90.8	60	231.7	118.0
21	18.7	09.5	81	72.2	36.8	141	125.6	64.0	201	179.1	91.3	261	232.6	118.5
22	19.6	10.0	82	73.1	37.2	42	126.5	64.5	02	180.0	91.7	62	233.4	118.9
23	20.5	10.4	83	74.0	37.7	43	127.4	64.9	03	180.9	92.2	63	234.3	119.4
24	21.4	10.9	84	74.8	38.1	44	128.3	65.4	04	181.8	92.6	64	235.2	119.9
25	22.3	11.3	85	75.7	38.6	45	129.2	65.8	05	182.7	93.1	65	236.1	120.3
26	23.2	11.8	86	76.6	39.0	46	130.1	66.3	06	183.5	93.5	66	237.0	120.8
27	24.1	12.3	87	77.5	39.5	47	131.0	66.7	07	184.4	94.0	67	237.9	121.2
28	24.9	12.7	88	78.4	40.0	48	131.9	67.2	08	185.3	94.4	68	238.8	121.7
29	25.8	13.2	89	79.3	40.4	49	132.8	67.6	09	186.2	94.9	69	239.7	122.1
30	26.7	13.6	90	80.2	40.9	50	133.7	68.1	10	187.1	95.3	70	240.6	122.6
31	27.6	14.1	91	81.1	41.3	151	134.5	68.6	211	188.0	95.8	271	241.5	123.0
32	28.5	14.5	92	82.0	41.8	52	135.4	69.0	12	188.9	96.2	72	242.4	123.5
33	29.4	15.0	93	82.9	42.2	53	136.3	69.5	13	189.8	96.7	73	243.2	123.9
34	30.3	15.4	94	83.8	42.7	54	137.2	69.9	14	190.7	97.2	74	244.1	124.4
35	31.2	15.9	95	84.6	43.1	55	138.1	70.4	15	191.6	97.6	75	245.0	124.8
36	32.1	16.3	96	85.5	43.6	56	139.0	70.8	16	192.5	98.1	76	245.9	125.3
37	33.0	16.8	97	86.4	44.0	57	139.9	71.3	17	193.3	98.5	77	246.8	125.8
38	33.9	17.3	98	87.3	44.5	58	140.8	71.7	18	194.2	99.0	78	247.7	126.2
39	34.7	17.7	99	88.2	44.9	59	141.7	72.2	19	195.1	99.4	79	248.6	126.7
40	35.6	18.2	100	89.1	45.4	60	142.6	72.6	20	196.0	99.9	80	249.5	127.1
41	36.5	18.6	101	90.0	45.9	161	143.5	73.1	221	196.9	100.3	281	250.4	127.6
42	37.4	19.1	02	90.9	46.3	62	144.3	73.5	22	197.8	100.8	82	251.3	128.0
43	38.3	19.5	03	91.8	46.8	63	145.2	74.0	23	198.7	101.2	83	252.2	128.5
44	39.2	20.0	04	92.7	47.2	64	146.1	74.5	24	199.6	101.7	84	253.0	128.9
45	40.1	20.4	05	93.6	47.7	65	147.0	74.9	25	200.5	102.1	85	253.9	129.4
46	41.0	20.9	06	94.4	48.1	66	147.9	75.4	26	201.4	102.6	86	254.8	129.8
47	41.9	21.3	07	95.3	48.6	67	148.8	75.8	27	202.3	103.1	87	255.7	130.3
48	42.8	21.8	08	96.2	49.0	68	149.7	76.3	28	203.1	103.5	88	256.6	130.7
49	43.7	22.2	09	97.1	49.5	69	150.6	76.7	29	204.0	104.0	89	257.5	131.2
50	44.6	22.7	10	98.0	49.9	70	151.5	77.2	30	204.9	104.4	90	258.4	131.7
51	45.4	23.2	111	98.9	50.4	171	152.4	77.6	231	205.8	104.9	291	259.3	132.1
52	46.3	23.6	12	99.8	50.8	72	153.3	78.1	32	206.7	105.3	92	260.2	132.6
53	47.2	24.1	13	100.7	51.3	73	154.1	78.5	33	207.6	105.8	93	261.1	133.0
54	48.1	24.5	14	101.6	51.8	74	155.0	79.0	34	208.5	106.2	94	262.0	133.5
55	49.0	25.0	15	102.5	52.2	75	155.9	79.4	35	209.4	106.7	95	262.8	133.9
56	49.9	25.4	16	103.4	52.7	76	156.8	79.9	36	210.3	107.1	96	263.7	134.4
57	50.8	25.9	17	104.2	53.1	77	157.7	80.4	37	211.2	107.6	97	264.6	134.8
58	51.7	26.3	18	105.1	53.6	78	158.6	80.8	38	212.1	108.0	98	265.5	135.3
59	52.6	26.8	19	106.0	54.0	79	159.5	81.3	39	213.0	108.5	99	266.4	135.7
60	53.5	27.2	20	106.9	54.5	80	160.4	81.7	40	213.8	109.0	300	267.3	136.2
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 63 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 28 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.5	61	53.9	28.6	121	106.8	56.8	181	159.8	85.0	241	212.8	113.1
2	01.8	00.9	62	54.7	29.1	22	107.7	57.3	82	160.7	85.4	42	213.7	113.6
3	02.6	01.4	63	55.6	29.6	23	108.6	57.7	83	161.6	85.9	43	214.6	114.1
4	03.5	01.9	64	56.5	30.0	24	109.5	58.2	84	162.5	86.4	44	215.4	114.6
5	04.4	02.3	65	57.4	30.5	25	110.4	58.7	85	163.3	86.9	45	216.3	115.0
6	05.3	02.8	66	58.3	31.0	26	111.3	59.2	86	164.2	87.3	46	217.2	115.5
7	06.2	03.3	67	59.2	31.5	27	112.1	59.6	87	165.1	87.8	47	218.1	116.0
8	07.1	03.8	68	60.0	31.9	28	113.0	60.1	88	166.0	88.3	48	219.0	116.4
9	07.9	04.2	69	60.9	32.4	29	113.9	60.6	89	166.9	88.7	49	219.9	116.9
10	08.8	04.7	70	61.8	32.9	30	114.8	61.0	90	167.8	89.2	50	220.7	117.4
11	09.7	05.2	71	62.7	33.3	131	115.7	61.5	191	168.6	89.7	251	221.6	117.8
12	10.6	05.6	72	63.6	33.8	32	116.5	62.0	92	169.5	90.1	52	222.5	118.3
13	11.5	06.1	73	64.5	34.3	33	117.4	62.4	93	170.4	90.6	53	223.4	118.8
14	12.4	06.6	74	65.3	34.7	34	118.3	62.9	94	171.3	91.1	54	224.3	119.2
15	13.2	07.0	75	66.2	35.2	35	119.2	63.4	95	172.2	91.5	55	225.2	119.7
16	14.1	07.5	76	67.1	35.7	36	120.1	63.8	96	173.1	92.0	56	226.0	120.2
17	15.0	08.0	77	68.0	36.1	37	121.0	64.3	97	173.9	92.5	57	226.9	120.7
18	15.9	08.5	78	68.9	36.6	38	121.8	64.8	98	174.8	93.0	58	227.8	121.1
19	16.8	08.9	79	69.8	37.1	39	122.7	65.3	99	175.7	93.4	59	228.7	121.6
20	17.7	09.4	80	70.6	37.6	40	123.6	65.7	200	176.6	93.9	60	229.6	122.1
21	18.5	09.9	81	71.5	38.0	141	124.5	66.2	201	177.5	94.4	261	230.4	122.5
22	19.4	10.3	82	72.4	38.5	42	125.4	66.7	02	178.4	94.8	62	231.3	123.0
23	20.3	10.8	83	73.3	39.0	43	126.3	67.1	03	179.2	95.3	63	232.2	123.5
24	21.2	11.3	84	74.2	39.4	44	127.1	67.6	04	180.1	95.8	64	233.1	123.9
25	22.1	11.7	85	75.1	39.9	45	128.0	68.1	05	181.0	96.2	65	234.0	124.4
26	23.0	12.2	86	75.9	40.4	46	128.9	68.5	06	181.9	96.7	66	234.9	124.9
27	23.8	12.7	87	76.8	40.8	47	129.8	69.0	07	182.8	97.2	67	235.7	125.3
28	24.7	13.1	88	77.7	41.3	48	130.7	69.5	08	183.7	97.7	68	236.6	125.8
29	25.6	13.6	89	78.6	41.8	49	131.6	70.0	09	184.5	98.1	69	237.5	126.3
30	26.5	14.1	90	79.5	42.3	50	132.4	70.4	10	185.4	98.6	70	238.4	126.8
31	27.4	14.6	91	80.3	42.7	151	133.3	70.9	211	186.3	99.1	271	239.3	127.2
32	28.3	15.0	92	81.2	43.2	52	134.2	71.4	12	187.2	99.5	72	240.2	127.7
33	29.1	15.5	93	82.1	43.7	53	135.1	71.8	13	188.1	100.0	73	241.0	128.2
34	30.0	16.0	94	83.0	44.1	54	136.0	72.3	14	189.0	100.5	74	241.9	128.6
35	30.9	16.4	95	83.9	44.6	55	136.9	72.8	15	189.8	100.9	75	242.8	129.1
36	31.8	16.9	96	84.8	45.1	56	137.7	73.2	16	190.7	101.4	76	243.7	129.6
37	32.7	17.4	97	85.6	45.5	57	138.6	73.7	17	191.6	101.9	77	244.6	130.0
38	33.6	17.8	98	86.5	46.0	58	139.5	74.2	18	192.5	102.3	78	245.5	130.5
39	34.4	18.3	99	87.4	46.5	59	140.4	74.6	19	193.4	102.8	79	246.3	131.0
40	35.3	18.8	100	88.3	46.9	60	141.3	75.1	20	194.2	103.3	80	247.2	131.5
41	36.2	19.2	101	89.2	47.4	161	142.2	75.6	221	195.1	103.8	281	248.1	131.9
42	37.1	19.7	02	90.1	47.9	62	143.0	76.1	22	196.0	104.2	82	249.0	132.4
43	38.0	20.2	03	90.9	48.4	63	143.9	76.5	23	196.9	104.7	83	249.9	132.9
44	38.8	20.7	04	91.8	48.8	64	144.8	77.0	24	197.8	105.2	84	250.8	133.3
45	39.7	21.1	05	92.7	49.3	65	145.7	77.5	25	198.7	105.6	85	251.6	133.8
46	40.6	21.6	06	93.6	49.8	66	146.6	77.9	26	199.5	106.1	86	252.5	134.3
47	41.5	22.1	07	94.5	50.2	67	147.5	78.4	27	200.4	106.6	87	253.4	134.7
48	42.4	22.5	08	95.4	50.7	68	148.3	78.9	28	201.3	107.0	88	254.3	135.2
49	43.3	23.0	09	96.2	51.2	69	149.2	79.3	29	202.2	107.5	89	255.2	135.7
50	44.1	23.5	10	97.1	51.6	70	150.1	79.8	30	203.1	108.0	90	256.1	136.1
51	45.0	23.9	111	98.0	52.1	171	151.0	80.3	231	204.0	108.4	291	256.9	136.6
52	45.9	24.4	12	98.9	52.6	72	151.9	80.7	32	204.8	108.9	92	257.8	137.1
53	46.8	24.9	13	99.8	53.1	73	152.7	81.2	33	205.7	109.4	93	258.7	137.6
54	47.7	25.4	14	100.7	53.5	74	153.6	81.7	34	206.6	109.9	94	259.6	138.0
55	48.6	25.8	15	101.5	54.0	75	154.5	82.2	35	207.5	110.3	95	260.5	138.5
56	49.4	26.3	16	102.4	54.5	76	155.4	82.6	36	208.4	110.8	96	261.4	139.0
57	50.3	26.8	17	103.3	54.9	77	156.3	83.1	37	209.3	111.3	97	262.2	139.4
58	51.2	27.2	18	104.2	55.4	78	157.2	83.6	38	210.1	111.7	98	263.1	139.9
59	52.1	27.7	19	105.1	55.9	79	158.0	84.0	39	211.0	112.2	99	264.0	140.4
60	53.0	28.2	20	106.0	56.3	80	158.9	84.5	40	211.9	112.7	300	264.9	140.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 29 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.5	61	53.4	29.6	121	105.8	58.7	181	158.3	87.8	241	210.8	116.8
2	01.7	01.0	62	54.2	30.1	22	106.7	59.1	82	159.2	88.2	42	211.7	117.3
3	02.6	01.5	63	55.1	30.5	23	107.6	59.6	83	160.1	88.7	43	212.5	117.8
4	03.5	01.9	64	56.0	31.0	24	108.5	60.1	84	160.9	89.2	44	213.4	118.3
5	04.4	02.4	65	56.9	31.5	25	109.3	60.6	85	161.8	89.7	45	214.3	118.8
6	05.2	02.9	66	57.7	32.0	26	110.2	61.1	86	162.7	90.2	46	215.2	119.3
7	06.1	03.4	67	58.6	32.5	27	111.1	61.6	87	163.6	90.7	47	216.0	119.7
8	07.0	03.9	68	59.5	33.0	28	112.0	62.1	88	164.4	91.1	48	216.9	120.2
9	07.9	04.4	69	60.3	33.5	29	112.8	62.5	89	165.3	91.6	49	217.8	120.7
10	08.7	04.8	70	61.2	33.9	30	113.7	63.0	90	166.2	92.1	50	218.7	121.2
11	09.6	05.3	71	62.1	34.4	131	114.6	63.5	191	167.1	92.6	251	219.5	121.7
12	10.5	05.8	72	63.0	34.9	32	115.4	64.0	92	167.9	93.1	52	220.4	122.2
13	11.4	06.3	73	63.8	35.4	33	116.3	64.5	93	168.8	93.6	53	221.3	122.7
14	12.2	06.8	74	64.7	35.9	34	117.2	65.0	94	169.7	94.1	54	222.2	123.1
15	13.1	07.3	75	65.6	36.4	35	118.1	65.4	95	170.6	94.5	55	223.0	123.6
16	14.0	07.8	76	66.5	36.8	36	118.9	65.9	96	171.4	95.0	56	223.9	124.1
17	14.9	08.2	77	67.3	37.3	37	119.8	66.4	97	172.3	95.5	57	224.8	124.6
18	15.7	08.7	78	68.2	37.8	38	120.7	66.9	98	173.2	96.0	58	225.7	125.1
19	16.6	09.2	79	69.1	38.3	39	121.6	67.4	99	174.0	96.5	59	226.5	125.6
20	17.5	09.7	80	70.0	38.8	40	122.4	67.9	200	174.9	97.0	60	227.4	126.1
21	18.4	10.2	81	70.8	39.3	141	123.3	68.4	201	175.8	97.4	261	228.3	126.5
22	19.2	10.7	82	71.7	39.8	42	124.2	68.8	02	176.7	97.9	62	229.2	127.0
23	20.1	11.2	83	72.6	40.2	43	125.1	69.3	03	177.5	98.4	63	230.0	127 5
24	21.0	11.6	84	73.5	40.7	44	125.9	69.8	04	178.4	98.9	64	230.9	128.0
25	21.9	12.1	85	74.3	41.2	45	126.8	70.3	05	179.3	99.4	65	231.8	128.5
26	22.7	12.6	86	75.2	41.7	46	127.7	70.8	06	180.2	99.9	66	232.6	129.0
27	23.6	13.1	87	76.1	42.2	47	128.6	71.3	07	181.0	100.4	67	233.5	129.4
28	24.5	13.6	88	77.0	42.7	48	129.4	71.8	08	181.9	100.8	68	234.4	129.9
29	25.4	14.1	89	77.8	43.1	49	130.3	72.2	09	182.8	101.3	69	235.3	130.4
30	26.2	14.5	90	78.7	43.6	50	131.2	72.7	10	183.7	101.8	70	236.1	130.9
31	27.1	15.0	91	79.6	44.1	151	132.1	73.2	211	184.5	102.3	271	237.0	131.4
32	28.0	15.5	92	80.5	44.6	52	132.9	73.7	12	185.4	102.8	72	237.9	131.9
33	28.9	16.0	93	81.3	45.1	53	133.8	74.2	13	186.3	103.3	73	238.8	132.4
34	29.7	16.5	94	82.2	45.6	54	134.7	74.7	14	187.2	103.7	74	239.6	132.8
35	30.6	17.0	95	83.1	46.1	55	135.6	75.1	15	188.0	104.2	75	240.5	133.3
36	31.5	17.5	96	84.0	46.5	56	136.4	75.6	16	188.9	104.7	76	241.4	133.8
37	32.4	17.9	97	84.8	47.0	57	137.3	76.1	17	189.8	105.2	77	242.3	134.3
38	33.2	18.4	98	85.7	47.5	58	138.2	76.6	18	190.7	105.7	78	243.1	134.8
39	34.1	18.9	99	86.6	48.0	59	139.1	77.1	19	191.5	106.2	79	244.0	135.3
40	35.0	19.4	100	87.5	48.5	60	139.9	77.6	20	192.4	106.7	80	244.9	135.7
41	35.9	19.9	101	88.3	49.0	161	140.8	78.1	221	193.3	107.1	281	245.8	136.2
42	36.7	20.4	02	89.2	49.5	62	141.7	78.5	22	194.2	107.6	82	246.6	136.7
43	37.6	20.8	03	90.1	49.9	63	142.6	79.0	23	195.0	108.1	83	247.5	137.2
44	38.5	21.3	04	91.0	50.4	64	143.4	79.5	24	195.9	108.6	84	248.4	137.7
45	39.4	21.8	05	91.8	50.9	65	144.3	80.0	25	196.8	109.1	85	249.3	138.2
46	40.2	22.3	06	92.7	51.4	66	145.2	80.5	26	197.7	109.6	86	250.1	138.7
47	41.1	22.8	07	93.6	51.9	67	146.1	81.0	27	198.5	110.1	87	251.0	139.1
48	42.0	23.3	08	94.5	52.4	68	146.9	81.4	28	199.4	110.5	88	251.9	139.6
49	42.9	23.8	09	95.3	52.8	69	147.8	81.9	29	200.3	111.0	89	252.8	140.1
50	43.7	24.2	10	96.2	53.3	70	148.7	82.4	30	201.2	111.5	90	253.6	140.6
51	44.6	24.7	111	97.1	53.8	171	149.6	82.9	231	202.0	112.0	291	254.5	141.1
52	45.5	25.2	12	98.0	54.3	72	150.4	83.4	32	202.9	112.5	92	255.4	141.6
53	46.4	25.7	13	98.8	54.8	73	151.3	83.9	33	203.8	113.0	93	256.3	142.0
54	47.2	26.2	14	99.7	55.3	74	152.2	84.4	34	204.7	113.4	94	257.1	142.5
55	48.1	26.7	15	100.6	55.8	75	153.1	84.8	35	205.5	113.9	95	258.0	143.0
56	49.0	27.1	16	101.5	56.2	76	153.9	85.3	36	206.4	114.4	96	258.9	143.5
57	49.9	27.6	17	102.3	56.7	77	154.8	85.8	37	207.3	114.9	97	259.8	144.c
58	50.7	28.1	18	103.2	57.2	78	155.7	86.3	38	208.2	115.4	98	260.6	144.5
59	51.6	28.6	19	104.1	57.7	79	156.6	86.8	39	209.0	115.9	99	261.5	145 0
60	52.5	29.1	20	105.0	58.2	80	157.4	87.3	40	209.9	116.4	300	262.4	145.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II

Difference of Latitude and Departure for 30 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat	Dep.
1	00.9	00.5	61	52.8	30.5	121	104.8	60.5	181	156.8	90.5	241	208.7	120.5
2	01.7	01.0	62	53.7	31.0	22	105.7	61.0	82	157.6	91.0	42	209.6	121.0
3	02.6	01.5	63	54.6	31.5	23	106.5	61.5	83	158.5	91.5	43	210.4	121.5
4	03.5	02.0	64	55.4	32.0	24	107.4	62.0	84	159.3	92.0	44	211.3	122.0
5	04.3	02.5	65	56.3	32.5	25	108.3	62.5	85	160.2	92.5	45	212.2	122.5
6	05.2	03.0	66	57.2	33.0	26	109.1	63.0	86	161.1	93.0	46	213.0	123.0
7	06.1	03.5	67	58.0	33.5	27	110.0	63.5	87	161.9	93.5	47	213.9	123.5
8	06.9	04.0	68	58.9	34.0	28	110.9	64.0	88	162.8	94.0	48	214.8	124.0
9	07.8	04.5	69	59.8	34.5	29	111.7	64.5	89	163.7	94.5	49	215.6	124.5
10	08.7	05.0	70	60.6	35.0	30	112.6	65.0	90	164.5	95.0	50	216.5	125.0
11	09.5	05.5	71	61.5	35.5	131	113.4	65.5	191	165.4	95.5	251	217.4	125.5
12	10.4	06.0	72	62.4	36.0	32	114.3	66.0	92	166.3	96.0	52	218.2	126.0
13	11.3	06.5	73	63.2	36.5	33	115.2	66.5	93	167.1	96.5	53	219.1	126.5
14	12.1	07.0	74	64.1	37.0	34	116.0	67.0	94	168.0	97.0	54	220.0	127.0
15	13.0	07.5	75	65.0	37.5	35	116.9	67.5	95	168.9	97.5	55	220.8	127.5
16	13.9	08.0	76	65.8	38.0	36	117.8	68.0	96	169.7	98.0	56	221.7	128.0
17	14.7	08.5	77	66.7	38.5	37	118.6	68.5	97	170.6	98.5	57	222.6	128.5
18	15.6	09.0	78	67.5	39.0	38	119.5	69.0	98	171.5	99.0	58	223.4	129.0
19	16.5	09.5	79	68.4	39.5	39	120.4	69.5	99	172.3	99.5	59	224.3	129.5
20	17.3	10.0	80	69.3	40.0	40	121.2	70.0	200	173.2	100.0	60	225.2	130.0
21	18.2	10.5	81	70.1	40.5	141	122.1	70.5	201	174.1	100.5	261	226.0	130.5
22	19.1	11.0	82	71.0	41.0	42	123.0	71.0	02	174.9	101.0	62	226.9	131.0
23	19.9	11.5	83	71.9	41.5	43	123.8	71.5	03	175.8	101.5	63	227.8	131.5
24	20.8	12.0	84	72.7	42.0	44	124.7	72.0	04	176.7	102.0	64	228.6	132.0
25	21.7	12.5	85	73.6	42.5	45	125.6	72.5	05	177.5	102.5	65	229.5	132.5
26	22.5	13.0	86	74.5	43.0	46	126.4	73.0	06	178.4	103.0	66	230.4	133.0
27	23.4	13.5	87	75.3	43.5	47	127.3	73.5	07	179.3	103.5	67	231.2	133.5
28	24.2	14.0	88	76.2	44.0	48	128.2	74.0	08	180.1	104.0	68	232.1	134.0
29	25.1	14.5	89	77.1	44.5	49	129.0	74.5	09	181.0	104.5	69	233.0	134.5
30	26.0	15.0	90	77.9	45.0	50	129.9	75.0	10	181.9	105.0	70	233.8	135.0
31	26.8	15.5	91	78.8	45.5	151	130.8	75.5	211	182.7	105.5	271	234.7	135.5
32	27.7	16.0	92	79.7	46.0	52	131.6	76.0	12	183.6	106.0	72	235.6	136.0
33	28.6	16.5	93	80.5	46.5	53	132.5	76.5	13	184.5	106.5	73	236.4	136.5
34	29.4	17.0	94	81.4	47.0	54	133.4	77.0	14	185.3	107.0	74	237.3	137.0
35	30.3	17.5	95	82.3	47.5	55	134.2	77.5	15	186.2	107.5	75	238.2	137.5
36	31.2	18.0	96	83.1	48.0	56	135.1	78.0	16	187.1	108.0	76	239.0	138.0
37	32.0	18.5	97	84.0	48.5	57	136.0	78.5	17	187.9	108.5	77	239.9	138.5
38	32.9	19.0	98	84.9	49.0	58	136.8	79.0	18	188.8	109.0	78	240.8	139.0
39	33.8	19.5	99	85.7	49.5	59	137.7	79.5	19	189.7	109.5	79	241.6	139.5
40	34.6	20.0	100	86.6	50.0	60	138.6	80.0	20	190.5	110.0	80	242.5	140.0
41	35.5	20.5	101	87.5	50.5	161	139.4	80.5	221	191.4	110.5	281	243.4	140.5
42	36.4	21.0	02	88.3	51.0	62	140.3	81.0	22	192.3	111.0	82	244.2	141.0
43	37.2	21.5	03	89.2	51.5	63	141.2	81.5	23	193.1	111.5	83	245.1	141.5
44	38.1	22.0	04	90.1	52.0	64	142.0	82.0	24	194.0	112.0	84	246.0	142.0
45	39.0	22.5	05	90.9	52.5	65	142.9	82.5	25	194.9	112.5	85	246.8	142.5
46	39.8	23.0	06	91.8	53.0	66	143.8	83.0	26	195.7	113.0	86	247.7	143.0
47	40.7	23.5	07	92.7	53.5	67	144.6	83.5	27	196.6	113.5	87	248.5	143.5
48	41.6	24.0	08	93.5	54.0	68	145.5	84.0	28	197.5	114.0	88	249.4	144.0
49	42.4	24.5	09	94.4	54.5	69	146.4	84.5	29	198.3	114.5	89	250.3	144.5
50	43.3	25.0	10	95.3	55.0	70	147.2	85.0	30	199.2	115.0	90	251.1	145.0
51	44.2	25.5	111	96.1	55.5	171	148.1	85.5	231	200.1	115.5	291	252.0	145.5
52	45.0	26.0	12	97.0	56.0	72	149.0	86.0	32	200.9	116.0	92	252.9	146.0
53	45.9	26.5	13	97.9	56.5	73	149.8	86.5	33	201.8	116.5	93	253.7	146.5
54	46.8	27.0	14	98.7	57.0	74	150.7	87.0	34	202.6	117.0	94	254.6	147.0
55	47.6	27.5	15	99.6	57.5	75	151.6	87.5	35	203.5	117.5	95	255.5	147.5
56	48.5	28.0	16	100.5	58.0	76	152.4	88.0	36	204.4	118.0	96	256.3	148.0
57	49.4	28.5	17	101.3	58.5	77	153.3	88.5	37	205.2	118.5	97	257.2	148.5
58	50.2	29.0	18	102.2	59.0	78	154.2	89.0	38	206.1	119.0	98	258.1	149.0
59	51.1	29.5	19	103.1	59.5	79	155.0	89.5	39	207.0	119.5	99	258.9	149.5
60	52.0	30.0	20	103.9	60.0	80	155.9	90.0	40	207.8	120.0	300	259.8	150.0
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 31 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.5	61	52.3	31.4	121	103.7	62.3	181	155.1	93.2	241	206.6	124.1
2	01.7	01.0	62	53.1	31.9	22	104.6	62.8	82	156.0	93.7	42	207.4	124.6
3	02.6	01.5	63	54.0	32.4	23	105.4	63.3	83	156.9	94.3	43	208.3	125.2
4	03.4	02.1	64	54.9	33.0	24	106.3	63.9	84	157.7	94.8	44	209.1	125.7
5	04.3	02.6	65	55.7	33.5	25	107.1	64.4	85	158.6	95.3	45	210.0	126.2
6	05.1	03.1	66	56.6	34.0	26	108.0	64.9	86	159.4	95.8	46	210.9	126.7
7	06.0	03.6	67	57.4	34.5	27	108.9	65.4	87	160.3	96.3	47	211.7	127.2
8	06.9	04.1	68	58.3	35.0	28	109.7	65.9	88	161.1	96.8	48	212.6	127.7
9	07 7	04.6	69	59.1	35.5	29	110.6	66.4	89	162.0	97.3	49	213.4	128.2
10	08.6	05.2	70	60.0	36.1	30	111.4	67.0	90	162.9	97.9	50	214.3	128.8
11	09.4	05.7	71	60.9	36.6	131	112.3	67.5	191	163.7	98.4	251	215.1	129.3
12	10.3	06.2	72	61.7	37.1	32	113.1	68.0	92	164.6	98.9	52	216.0	129.8
13	11.1	06.7	73	62.6	37.6	33	114.0	68.5	93	165.4	99.4	53	216.9	130.3
14	12.0	07.2	74	63.4	38.1	34	114.9	69.0	94	166.3	99.9	54	217.7	130.8
15	12.9	07.7	75	64.3	38.6	35	115.7	69.5	95	167.1	100.4	55	218.6	131.3
16	13.7	08.2	76	65.1	39.1	36	116.6	70.0	96	168.0	100.9	56	219.4	131.8
17	14.6	08.8	77	66.0	39.7	37	117.4	70.6	97	168.9	101.5	57	220.3	132.4
18	15.4	09.3	78	66.9	40.2	38	118.3	71.1	98	169.7	102.0	58	221.1	132.9
19	16.3	09.8	79	67.7	40.7	39	119.1	71.6	99	170.6	102.5	59	222.0	133.4
20	17.1	10.3	80	68.6	41.2	40	120.0	72.1	200	171.4	103.0	60	222.9	133.9
21	18.0	10.8	81	69.4	41.7	141	120.9	72.6	201	172.3	103.5	261	223.7	134.4
22	18.9	11.3	82	70.3	42 2	42	121.7	73.1	02	173.1	104.0	62	224.6	134.9
23	19.7	11.8	83	71.1	42.7	43	122.6	73.7	03	174.0	104.6	63	225.4	135.5
24	20.6	12.4	84	72.0	43.3	44	123.4	74.2	04	174.9	105.1	64	226.3	136.0
25	21.4	12.9	85	72.9	43.8	45	124.3	74.7	05	175.7	105.6	65	227.1	136.5
26	22.3	13.4	86	73.7	44.3	46	125.1	75.2	06	176.6	106.1	66	228.0	137.0
27	23.1	13.9	87	74.6	44.8	47	126.0	75.7	07	177.4	106.6	67	228.9	137.5
28	24.0	14.4	88	75.4	45.3	48	126.9	76.2	08	178.3	107.1	68	229.7	138.0
29	24.9	14.9	89	76.3	45.8	49	127.7	76.7	09	179.1	107.6	69	230.6	138.5
30	25.7	15.5	90	77.1	46.4	50	128.6	77.3	10	180.0	108.2	70	231.4	139.1
31	26.6	16.0	91	78.0	46.9	151	129.4	77.8	211	180.9	108.7	271	232.3	139.6
32	27.4	16.5	92	78.9	47.4	52	130.3	78.3	12	181.7	109.2	72	233.1	140.1
33	28.3	17.0	93	79.7	47.9	53	131.1	78.8	13	182.6	109.7	73	234.0	140.6
34	29.1	17.5	94	80.6	48.4	54	132.0	79.3	14	183.4	110.2	74	234.9	141.1
35	30.0	18.0	95	81.4	48.9	55	132.9	79.8	15	184.3	110.7	75	235.7	141.6
36	30.9	18.5	96	82.3	49.4	56	133.7	80.3	16	185.1	111.2	76	236.6	142.2
37	31.7	19.1	97	83.1	50.0	57	134.6	80.9	17	186.0	111.8	77	237.4	142.7
38	32.6	19.6	98	84.0	50.5	58	135.4	81.4	18	186.9	112.3	78	238.3	143.2
39	33.4	20.1	99	84.9	51.0	59	136.3	81.9	19	187.7	112.8	79	239.1	143.7
40	34.3	20.6	100	85.7	51.5	60	137.1	82.4	20	188.6	113.3	80	240.0	144.2
41	35.1	21.1	101	86.6	52.0	161	138.0	82.9	221	189.4	113.8	281	240.9	144.7
42	36.0	21.6	02	87.4	52.5	62	138.9	83.4	22	190.3	114.3	82	241.7	145.2
43	36.9	22.1	03	88.3	53.0	63	139.7	84.0	23	191.1	114.9	83	242.6	145.8
44	37.7	22.7	04	89.1	53.6	64	140.6	84.5	24	192.0	115.4	84	243.4	146.3
45	38.6	23.2	05	90.0	54.1	65	141.4	85.0	25	192.9	115.9	85	244.3	146.8
46	39.4	23.7	06	90.9	54.6	66	142.3	85.5	26	193.7	116.4	86	245.1	147.3
47	40.3	24.2	07	91.7	55.1	67	143.1	86.0	27	194.6	116.9	87	246.0	147.8
48	41.1	24.7	08	92.6	55.6	68	144.0	86.5	28	195.4	117.4	88	246.9	148.3
49	42.0	25.2	09	93.4	56.1	69	144.9	87.0	29	196.3	117.9	89	247.7	148.8
50	42.9	25.8	10	94.3	56.7	70	145.7	87.6	30	197.1	118.5	90	248.6	149.4
51	43.7	26.3	111	95.1	57.2	171	146.6	88.1	231	198.0	119 0	291	249.4	149.9
52	44.6	26.8	12	96.0	57.7	72	147.4	88.6	32	198.9	119.5	92	250.3	150.4
53	45.4	27.3	13	96.9	58.2	73	148.3	89.1	33	199.7	120.0	93	251.2	150.9
54	46.3	27.8	14	97.7	58.7	74	149.1	89.6	34	200.6	120.5	94	252.0	151.4
55	47.1	28.3	15	98.6	59.2	75	150.0	90.1	35	201.4	121.0	95	252.9	151.9
56	48.0	28.8	16	99.4	59.7	76	150.9	90.6	36	202.3	121.5	96	253.7	152.5
57	48.9	29.4	17	100.3	60.3	77	151.7	91.2	37	203.1	122.1	97	254.6	153.0
58	49.7	29.9	18	101.1	60.8	78	152.6	91.7	38	204.0	122.6	98	255.4	153.5
59	50.6	30.4	19	102.0	61.3	79	153.4	92.2	39	204.9	123.1	99	256.3	154.0
60	51.4	30.9	20	102.9	61.8	80	154.3	92.7	40	205.7	123.6	300	257.1	154.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 59 Degrees.

TABLE II.

Difference of Latitude and Departure for 32 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.5	61	51.7	32.3	121	102.6	64.1	181	153.5	95.9	241	204.4	127.7
2	01.7	01.1	62	52.6	32.9	22	103.5	64.7	82	154.3	96.4	42	205.2	128.2
3	02.5	01.6	63	53.4	33.4	23	104.3	65.2	83	155.2	97.0	43	206.1	128.8
4	03.4	02.1	64	54.3	33.9	24	105.2	65.7	84	156.0	97.5	44	206.9	129.3
5	04.2	02.6	65	55.1	34.4	25	106.0	66.2	85	156.9	98.0	45	207.8	129.8
6	05.1	03.2	66	56.0	35.0	26	106.9	66.8	86	157.7	98.6	46	208.6	130.4
7	05.9	03.7	67	56.8	35.5	27	107.7	67.3	87	158.6	99.1	47	209.5	130.9
8	06.8	04.2	68	57.7	36.0	28	108.6	67.8	88	159.4	99.6	48	210.3	131.4
9	07.6	04.8	69	58.5	36.6	29	109.4	68.4	89	160.3	100.2	49	211.2	131.9
10	08.5	05.3	70	59.4	37.1	30	110.2	68.9	90	161.1	100.7	50	212.0	132.5
11	09.3	05.8	71	60.2	37.6	131	111.1	69.4	191	162.0	101.2	251	212.9	133.0
12	10.2	06.4	72	61.1	38.2	32	111.9	69.9	92	162.8	101.7	52	213.7	133.5
13	11.0	06.9	73	61.9	38.7	33	112.8	70.5	93	163.7	102.3	53	214.6	134.1
14	11.9	07.4	74	62.8	39.2	34	113.6	71.0	94	164.5	102.8	54	215.4	134.6
15	12.7	07.9	75	63.6	39.7	35	114.5	71.5	95	165.4	103.3	55	216.3	135.1
16	13.6	08.5	76	64.5	40.3	36	115.3	72.1	96	166.2	103.9	56	217.1	135.7
17	14.4	09.0	77	65.3	40.8	37	116.2	72.6	97	167.1	104.4	57	217.9	136.2
18	15.3	09.5	78	66.1	41.3	38	117.0	73.1	98	167.9	104.9	58	218.8	136.7
19	16.1	10.1	79	67.0	41.9	39	117.9	73.7	99	168.8	105.5	59	219.6	137.2
20	17.0	10.6	80	67.8	42.4	40	118.7	74.2	200	169.6	106.0	60	220.5	137.8
21	17.8	11.1	81	68.7	42.9	141	119.6	74.7	201	170.5	106.5	261	221.3	138.3
22	18.7	11.7	82	69.5	43.5	42	120.4	75.2	02	171.3	107.0	62	222.2	138.8
23	19.5	12.2	83	70.4	44.0	43	121.3	75.8	03	172.2	107.6	63	223.0	139.4
24	20.4	12.7	84	71.2	44.5	44	122.1	76.3	04	173.0	108.1	64	223.9	139.9
25	21.2	13.2	85	72.1	45.0	45	123.0	76.8	05	173.8	108.6	65	224.7	140.4
26	22.0	13.8	86	72.9	45.6	46	123.8	77.4	06	174.7	109.2	66	225.6	141.0
27	22.9	14.3	87	73.8	46.1	47	124.7	77.9	07	175.5	109.7	67	226.4	141.5
28	23.7	14.8	88	74.6	46.6	48	125.5	78.4	08	176.4	110.2	68	227.3	142.0
29	24.6	15.4	89	75.5	47.2	49	126.4	79.0	09	177.2	110.8	69	228.1	142.5
30	25.4	15.9	90	76.3	47.7	50	127.2	79.5	10	178.1	111.3	70	229.0	143.1
31	26.3	16.4	91	77.2	48.2	151	128.1	80.0	211	178.9	111.8	271	229.8	143.6
32	27.1	17.0	92	78.0	48.8	52	128.9	80.5	12	179.8	112.3	72	230.7	144.1
33	28.0	17.5	93	78.9	49.3	53	129.8	81.1	13	180.6	112.9	73	231.5	144.7
34	28.8	18.0	94	79.7	49.8	54	130.6	81.6	14	181.5	113.4	74	232.4	145.2
35	29.7	18.5	95	80.6	50.3	55	131.4	82.1	15	182.3	113.9	75	233.2	145.7
36	30.5	19.1	96	81.4	50.9	56	132.3	82.7	16	183.2	114.5	76	234.1	146.3
37	31.4	19.6	97	82.3	51.4	57	133.1	83.2	17	184.0	115.0	77	234.9	146.8
38	32.2	20.1	98	83.1	51.9	58	134.0	83.7	18	184.9	115.5	78	235.8	147.3
39	33.1	20.7	99	84.0	52.5	59	134.8	84.3	19	185.7	116.1	79	236.6	147.8
40	33.9	21.2	100	84.8	53.0	60	135.7	84.8	20	186.6	116.6	80	237.5	148.4
41	34.8	21.7	101	85.7	53.5	161	136.5	85.3	221	187.4	117.1	281	238.3	148.9
42	35.6	22.3	02	86.5	54.1	62	137.4	85.8	22	188.3	117.6	82	239.1	149.4
43	36.5	22.8	03	87.3	54.6	63	138.2	86.4	23	189.1	118.2	83	240.0	150.0
44	37.3	23.3	04	88.2	55.1	64	139.1	86.9	24	190.0	118.7	84	240.8	150.5
45	38.2	23.8	05	89.0	55.6	65	139.9	87.4	25	190.8	119.2	85	241.7	151.0
46	39.0	24.4	06	89.9	56.2	66	140.8	88.0	26	191.7	119.8	86	242.5	151.6
47	39.9	24.9	07	90.7	56.7	67	141.6	88.5	27	192.5	120.3	87	243.4	152.1
48	40.7	25.4	08	91.6	57.2	68	142.5	89.0	28	193.4	120.8	88	244.2	152.6
49	41.6	26.0	09	92.4	57.8	69	143.3	89.6	29	194.2	121.4	89	245.1	153.1
50	42.4	26.5	10	93.3	58.3	70	144.2	90.1	30	195.1	121.9	90	245.9	153.7
51	43.3	27.0	111	94.1	58.8	171	145.0	90.6	231	195.9	122.4	291	246.8	154.2
52	44.1	27.6	12	95.0	59.4	72	145.9	91.1	32	196.7	122.9	92	247.6	154.7
53	44.9	28.1	13	95.8	59.9	73	146.7	91.7	33	197.6	123.5	93	248.5	155.3
54	45.8	28.6	14	96.7	60.4	74	147.6	92.2	34	198.4	124.0	94	249.3	155.8
55	46.6	29.1	15	97.5	60.9	75	148.4	92.7	35	199.3	124.5	95	250.2	156.3
56	47.5	29.7	16	98.4	61.5	76	149.3	93.3	36	200.1	125.1	96	251.0	156.9
57	48.3	30.2	17	99.2	62.0	77	150.1	93.8	37	201.0	125.6	97	251.9	157.4
58	49.2	30.7	18	100.1	62.5	78	151.0	94.3	38	201.8	126.1	98	252.7	157.9
59	50.0	31.3	19	100.9	63.1	79	151.8	94.9	39	202.7	126.7	99	253.6	158.4
60	50.9	31.8	20	101.8	63.6	80	152.6	95.4	40	203.5	127.2	300	254.4	159.0
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 58 Degrees.

TABLE II.

Difference of Latitude and Departure for 33 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.5	61	51.2	33.2	121	101.5	65.9	181	151.8	98.6	241	202.1	131.3
2	01.7	01.1	62	52.0	33.8	22	102.3	66.4	82	152.6	99.1	42	203.0	131.8
3	02.5	01.6	63	52.8	34.3	23	103.2	67.0	83	153.5	99.7	43	203.8	132.3
4	03.4	02.2	64	53.7	34.9	24	104.0	67.5	84	154.3	100.2	44	204.6	132.9
5	04.2	02.7	65	54.5	35.4	25	104.8	68.1	85	155.2	100.8	45	205.5	133.4
6	05.0	03.3	66	55.4	35.9	26	105.7	68.6	86	156.0	101.3	46	206.3	134.0
7	05.9	03.8	67	56.2	36.5	27	106.5	69.2	87	156.8	101.8	47	207.2	134.5
8	06.7	04.4	68	57.0	37.0	28	107.3	69.7	88	157.7	102.4	48	208.0	135.1
9	07.5	04.9	69	57.9	37.6	29	108.2	70.3	89	158.5	102.9	49	208.8	135.6
10	08.4	05.4	70	58.7	38.1	30	109.0	70.8	90	159.3	103.5	50	209.7	136.2
11	09.2	06.0	71	59.5	38.7	131	109.9	71.3	191	160.2	104.0	251	210.5	136.7
12	10.1	06.5	72	60.4	39.2	32	110.7	71.9	92	161.0	104.6	52	211.3	137.2
13	10.9	07.1	73	61.2	39.8	33	111.5	72.4	93	161.9	105.1	53	212.2	137.8
14	11.7	07.6	74	62.1	40.3	34	112.4	73.0	94	162.7	105.7	54	213.0	138.3
15	12.6	08.2	75	62.9	40.8	35	113.2	73.5	95	163.5	106.2	55	213.9	138.9
16	13.4	08.7	76	63.7	41.4	36	114.1	74.1	96	164.4	106.7	56	214.7	139.4
17	14.3	09.3	77	64.6	41.9	37	114.9	74.6	97	165.2	107.3	57	215.5	140.0
18	15.1	09.8	78	65.4	42.5	38	115.7	75.2	98	166.1	107.8	58	216.4	140.5
19	15.9	10.3	79	66.3	43.0	39	116.6	75.7	99	166.9	108.4	59	217.2	141.1
20	16.8	10.9	80	67.1	43.6	40	117.4	76.2	200	167.7	108.9	60	218.1	141.6
21	17.6	11.4	81	67.9	44.1	141	118.3	76.8	201	168.6	109.5	261	218.9	142.2
22	18.5	12.0	82	68.8	44.7	42	119.1	77.3	02	169.4	110.0	62	219.7	142.7
23	19.3	12.5	83	69.6	45.2	43	119.9	77.9	03	170.3	110.6	63	220.6	143.2
24	20.1	13.1	84	70.4	45.7	44	120.8	78.4	04	171.1	111.1	64	221.4	143.8
25	21.0	13.6	85	71.3	46.3	45	121.6	79.0	05	171.9	111.7	65	222.2	144.3
26	21.8	14.2	86	72.1	46.8	46	122.4	79.5	06	172.8	112.2	66	223.1	144.9
27	22.6	14.7	87	73.0	47.4	47	123.3	80.1	07	173.6	112.7	67	223.9	145.4
28	23.5	15.2	88	73.8	47.9	48	124.1	80.6	08	174.4	113.3	68	224.8	146 0
29	24.3	15.8	89	74.6	48.5	49	125.0	81.2	09	175.3	113.8	69	225.6	146.5
30	25.2	16.3	90	75.5	49.0	50	125.8	81.7	10	176.1	114.4	70	226.4	147.1
31	26.0	16.9	91	76.3	49.6	151	126.6	82.2	211	177.0	114.9	271	227.3	147.6
32	26.8	17.4	92	77.2	50.1	52	127.5	82.8	12	177.8	115.5	72	228.1	148.1
33	27.7	18.0	93	78.0	50.7	53	128.3	83.3	13	178.6	116.0	73	229.0	148.7
34	28.5	18.5	94	78.8	51.2	54	129.2	83.9	14	179.5	116.6	74	229.8	149.2
35	29.4	19.1	95	79.7	51.7	55	130.0	84.4	15	180.3	117.1	75	230.6	149.8
36	30.2	19.6	96	80.5	52.3	56	130.8	85.0	16	181.2	117.6	76	231.5	150.3
37	31.0	20.2	97	81.4	52.8	57	131.7	85.5	17	182.0	118.2	77	232.3	150.9
38	31.9	20.7	98	82.2	53.4	58	132.5	86.1	18	182.8	118.7	78	233.2	151.4
39	32.7	21.2	99	83.0	53.9	59	133.3	86.6	19	183.7	119.3	79	234.0	152.0
40	33.5	21.8	100	83.9	54.5	60	134.2	87.1	20	184.5	119.8	80	234.8	152.5
41	34.4	22.3	101	84.7	55.0	161	135.0	87.7	221	185.3	120.4	281	235.7	153.0
42	35.2	22.9	02	85.5	55.6	62	135.9	88.2	22	186.2	120.9	82	236.5	153.6
43	36.1	23.4	03	86.4	56.1	63	136.7	88.8	23	187.0	121.5	83	237.3	154.1
44	36.9	24.0	04	87.2	56.6	64	137.5	89.3	24	187.9	122.0	84	238.2	154.7
45	37.7	24.5	05	88.1	57.2	65	138.4	89.9	25	188.7	122.5	85	239.0	155.2
46	38.6	25.1	06	88.9	57.7	66	139.2	90.4	26	189.5	123.1	86	239.9	155.8
47	39.4	25.6	07	89.7	58.3	67	140.1	91.0	27	190.4	123.6	87	240.7	156.3
48	40.3	26.1	08	90.6	58.8	68	140.9	91.5	28	191.2	124.2	88	241.5	156.9
49	41.1	26.7	09	91.4	59.4	69	141.7	92.0	29	192.1	124.7	89	242.4	157.4
50	41.9	27.2	10	92.3	59.9	70	142.6	92.6	30	192.9	125.3	90	243.2	157.9
51	42.8	27.8	111	93.1	60.5	171	143.4	93.1	231	193.7	125.8	291	244.1	158.5
52	43.6	28.3	12	93.9	61.0	72	144.3	93.7	32	194.6	126.4	92	244.9	159.0
53	44.4	28.9	13	94.8	61.5	73	145.1	94.2	33	195.4	126.9	93	245.7	159.6
54	45.3	29.4	14	95.6	62.1	74	145.9	94.8	34	196.2	127.4	94	246.6	160.1
55	46.1	30.0	15	96.4	62.6	75	146.8	95.3	35	197.1	128.0	95	247.4	160.7
56	47.0	30.5	16	97.3	63.2	76	147.6	95.9	36	197.9	128.5	96	248.2	161.2
57	47.8	31.0	17	98.1	63.7	77	148.4	96.4	37	198.8	129.1	97	249.1	161.8
58	48.6	31.6	18	99.0	64.3	78	149.3	96.9	38	199.6	129.6	98	249.9	162.3
59	49.5	32.1	19	99.8	64.8	79	150.1	97.5	39	200.4	130.2	99	250.8	162.8
60	50.3	32.7	20	100.6	65.4	80	151.0	98.0	40	201.3	130.7	300	251.6	163.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 57 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 34 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	50.6	34.1	121	100.3	67.7	181	150.1	101.2	241	199.8	134.8
2	01.7	01.1	62	51.4	34.7	22	101.1	68.2	82	150.9	101.8	42	200.6	135.3
3	02.5	01.7	63	52.2	35.2	23	102.0	68.8	83	151.7	102.3	43	201.5	135.9
4	03.3	02.2	64	53.1	35.8	24	102.8	69.3	84	152.5	102.9	44	202.3	136.4
5	04.1	02.8	65	53.9	36.3	25	103.6	69.9	85	153.4	103.5	45	203.1	137.0
6	05.0	03.4	66	54.7	36.9	26	104.5	70.5	86	154.2	104.0	46	203.9	137.6
7	05.8	03.9	67	55.5	37.5	27	105.3	71.0	87	155.0	104.6	47	204.8	138.1
8	06.6	04.5	68	56.4	38.0	28	106.1	71.6	88	155.9	105.1	48	205.6	138.7
9	07.5	05.0	69	57.2	38.6	29	106.9	72.1	89	156.7	105.7	49	206.4	139.2
10	08.3	05.6	70	58.0	39.1	30	107.8	72.7	90	157.5	106.2	50	207.3	139.8
11	09.1	06.2	71	58.9	39.7	131	108.6	73.3	191	158.3	106.8	251	208.1	140.4
12	09.9	06.7	72	59.7	40.3	32	109.4	73.8	92	159.2	107.4	52	208.9	140.9
13	10.8	07.3	73	60.5	40.8	33	110.3	74.4	93	160.0	107.9	53	209.7	141.5
14	11.6	07.8	74	61.3	41.4	34	111.1	74.9	94	160.8	108.5	54	210.6	142.0
15	12.4	08.4	75	62.2	41.9	35	111.9	75.5	95	161.7	109.0	55	211.4	142.6
16	13.3	08.9	76	63.0	42.5	36	112.7	76.1	96	162.5	109.6	56	212.2	143.2
17	14.1	09.5	77	63.8	43.1	37	113.6	76.6	97	163.3	110.2	57	213.1	143.7
18	14.9	10.1	78	64.7	43.6	38	114.4	77.2	98	164.1	110.7	58	213.9	144.3
19	15.8	10.6	79	65.5	44.2	39	115.2	77.7	99	165.0	111.3	59	214.7	144.8
20	16.6	11.2	80	66.3	44.7	40	116.1	78.3	200	165.8	111.8	60	215.5	145.4
21	17.4	11.7	81	67.2	45.3	141	116.9	78.8	201	166.6	112.4	261	216.4	145.9
22	18.2	12.3	82	68.0	45.9	42	117.7	79.4	02	167.5	113.0	62	217.2	146.5
23	19.1	12.9	83	68.8	46.4	43	118.6	80.0	03	168.3	113.5	63	218.0	147.1
24	19.9	13.4	84	69.6	47.0	44	119.4	80.5	04	169.1	114.1	64	218.9	147.6
25	20.7	14.0	85	70.5	47.5	45	120.2	81.1	05	170.0	114.6	65	219.7	148.2
26	21.6	14.5	86	71.3	48.1	46	121.0	81.6	06	170.8	115.2	66	220.5	148.7
27	22.4	15.1	87	72.1	48.6	47	121.9	82.2	07	171.6	115.8	67	221.4	149.3
28	23.2	15.7	88	73.0	49.2	48	122.7	82.8	08	172.4	116.3	68	222.2	149.9
29	24.0	16.2	89	73.8	49.8	49	123.5	83.3	09	173.3	116.9	69	223.0	150.4
30	24.9	16.8	90	74.6	50.3	50	124.4	83.9	10	174.1	117.4	70	223.8	151.0
31	25.7	17.3	91	75.4	50.9	151	125.2	84.4	211	174.9	118.0	271	224.7	151.5
32	26.5	17.9	92	76.3	51.4	52	126.0	85.0	12	175.8	118.5	72	225.5	152.1
33	27.4	18.5	93	77.1	52.0	53	126.8	85.6	13	176.6	119.1	73	226.3	152.7
34	28.2	19.0	94	77.9	52.6	54	127.7	86.1	14	177.4	119.7	74	227.2	153.2
35	29.0	19.6	95	78.8	53.1	55	128.5	86.7	15	178.2	120.2	75	228.0	153.8
36	29.8	20.1	96	79.6	53.7	56	129.3	87.2	16	179.1	120.8	76	228.8	154.3
37	30.7	20.7	97	80.4	54.2	57	130.2	87.8	17	179.9	121.3	77	229.6	154.9
38	31.5	21.2	98	81.2	54.8	58	131.0	88.4	18	180.7	121.9	78	230.5	155.5
39	32.3	21.8	99	82.1	55.4	59	131.8	88.9	19	181.6	122.5	79	231.3	156.0
40	33.2	22.4	100	82.9	55.9	60	132.6	89.5	20	182.4	123.0	80	232.1	156.6
41	34.0	22.9	101	83.7	56.5	161	133.5	90.0	221	183.2	123.6	281	233.0	157.1
42	34.8	23.5	02	84.6	57.0	62	134.3	90.6	22	184.0	124.1	82	233.8	157.7
43	35.6	24.0	03	85.4	57.6	63	135.1	91.1	23	184.9	124.7	83	234.6	158.3
44	36.5	24.6	04	86.2	58.2	64	136.0	91.7	24	185.7	125.3	84	235.4	158.8
45	37.3	25.2	05	87.0	58.7	65	136.8	92.3	25	186.5	125.8	85	236.3	159.4
46	38.1	25.7	06	87.9	59.3	66	137.6	92.8	26	187.4	126.4	86	237.1	159.9
47	39.0	26.3	07	88.7	59.8	67	138.4	93.4	27	188.2	126.9	87	237.9	160.5
48	39.8	26.8	08	89.5	60.4	68	139.3	93.9	28	189.0	127.5	88	238.8	161.0
49	40.6	27.4	09	90.4	61.0	69	140.1	94.5	29	189.8	128.1	89	239.6	161.6
50	41.5	28.0	10	91.2	61.5	70	140.9	95.1	30	190.7	128.6	90	240.4	162.2
51	42.3	28.5	111	92.0	62.1	171	141.8	95.6	231	191.5	129.2	291	241.2	162.7
52	43.1	29.1	12	92.9	62.6	72	142.6	96.2	32	192.3	129.7	92	242.1	163.3
53	43.9	29.6	13	93.7	63.2	73	143.4	96.7	33	193.2	130.3	93	242.9	163.8
54	44.8	30.2	14	94.5	63.7	74	144.3	97.3	34	194.0	130.9	94	243.7	164.4
55	45.6	30.8	15	95.3	64.3	75	145.1	97.9	35	194.8	131.4	95	244.6	165.0
56	46.4	31.3	16	96.2	64.9	76	145.9	98.4	36	195.7	132.0	96	245.4	165.5
57	47.3	31.9	17	97.0	65.4	77	146.7	99.0	37	196.5	132.5	97	246.2	166.1
58	48.1	32.4	18	97.8	66.0	78	147.6	99.5	38	197.3	133.1	98	247.1	166.6
59	48.9	33.0	19	98.7	66.5	79	148.4	100.1	39	198.1	133.6	99	247.9	167.2
60	49.7	33.6	20	99.5	67.1	80	149.2	100.7	40	199.0	134.2	300	248.7	167.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 56 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 35 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	50.0	35.0	121	99.1	69.4	181	148.3	103.8	241	197.4	138.2
2	01.6	01.1	62	50.8	35.6	22	99.9	70.0	82	149.1	104 4	42	198.2	138.8
3	02.5	01.7	63	51.6	36.1	23	100.8	70.5	83	149.9	105.0	43	199.1	139.4
4	03.3	02.3	64	52.4	36.7	24	101.6	71.1	84	150.7	105.5	44	199.9	140.0
5	04.1	02.9	65	53.2	37.3	25	102.4	71.7	85	151.5	106.1	45	200.7	140.5
6	04.9	03.4	66	54.1	37.9	26	103.2	72.3	86	152.4	106.7	46	201.5	141.1
7	05.7	04.0	67	54.9	38.4	27	104.0	72.8	87	153.2	107.3	47	202.3	141.7
8	06.6	04.6	68	55.7	39.0	28	104.9	73.4	88	154.0	107.8	48	203.1	142.2
9	07.4	05.2	69	56.5	39.6	29	105.7	74.0	89	154.8	108.4	49	204.0	142.8
10	08.2	05.7	70	57.3	40.2	30	106.5	74.6	90	155.6	109.0	50	204.8	143.4
11	09.0	06.3	71	58.2	40.7	131	107.3	75.1	191	156.5	109.6	251	205.6	144.0
12	09.8	06.9	72	59.0	41.3	32	108.1	75.7	92	157.3	110.1	52	206.4	144.5
13	10.6	07.5	73	59.8	41.9	33	108.9	76.3	93	158.1	110.7	53	207.2	145.1
14	11.5	08.0	74	60.6	42.4	34	109.8	76.9	94	158.9	111.3	54	208.1	145 7
15	12.3	08.6	75	61.4	43.0	35	110.6	77.4	95	159.7	111.8	55	208.9	146.3
16	13.1	09.2	76	62.3	43.6	36	111.4	78.0	96	160.6	112.4	56	209 7	146.8
17	13.9	09.8	77	63.1	44.2	37	112.2	78.6	97	161.4	113.0	57	210.5	147.4
18	14.7	10.3	78	63.9	44.7	38	113.0	79.2	98	162.2	113.6	58	211.3	148.0
19	15.6	10.9	79	64.7	45.3	39	113.9	79.7	99	163.0	114.1	59	212.2	148.6
20	16.4	11.5	80	65.5	45.9	40	114.7	80.3	200	163.8	114.7	60	213.0	149.1
21	17.2	12.0	81	66.4	46.5	141	115.5	80.9	201	164.6	115.3	261	213.8	149.7
22	18.0	12.6	82	67.2	47.0	42	116.3	81.4	02	165.5	115.9	62	214.6	150.3
23	18.8	13.2	83	68.0	47.6	43	117.1	82.0	03	166.3	116.4	63	215.4	150.9
24	19.7	13.8	84	68.8	48.2	44	118.0	82.6	04	167.1	117.0	64	216.3	151.4
25	20.5	14.3	85	69.6	48.8	45	118.8	83.2	05	167.9	117.6	65	217.1	152.0
26	21.3	14.9	86	70.4	49.3	46	119.6	83.7	06	168.7	118.2	66	217.9	152 6
27	22.1	15.5	87	71.3	49.9	47	120.4	84.3	07	169.6	118.7	67	218.7	153.1
28	22.9	16.1	88	72.1	50.5	48	121.2	84.9	08	170.4	119.3	68	219.5	153.7
29	23.8	16.6	89	72.9	51.0	49	122.1	85.5	09	171.2	119.9	69	220.4	154.3
30	24.6	17.2	90	73.7	51.6	50	122.9	86.0	10	172.0	120.5	70	221.2	154.9
31	25.4	17.8	91	74.5	52.2	151	123.7	86.6	211	172.8	121.0	271	222.0	155.4
32	26.2	18.4	92	75.4	52.8	52	124.5	87.2	12	173.7	121.6	72	222.8	156.0
33	27.0	18.9	93	76.2	53.3	53	125.3	87.8	13	174.5	122.2	73	223.6	156.6
34	27.9	19.5	94	77.0	53.9	54	126.1	88.3	14	175.3	122.7	74	224.4	157.2
35	28.7	20.1	95	77.8	54.5	55	127.0	88.9	15	176.1	123.3	75	225.3	157.7
36	29.5	20.6	96	78.6	55.1	56	127.8	89.5	16	176.9	123.9	76	226.1	158.3
37	30.3	21.2	97	79.5	55.6	57	128.6	90.1	17	177.8	124.5	77	226.9	158.9
38	31.1	21.8	98	80.3	56.2	58	129.4	90.6	18	178.6	125.0	78	227.7	159.5
39	31.9	22.4	99	81.1	56.8	59	130.2	91.2	19	179.4	125.6	79	228.5	160.0
40	32.8	22.9	100	81.9	57.4	60	131.1	91.8	20	180.2	126.2	80	229.4	160.6
41	33.6	23.5	101	82.7	57.9	161	131.9	92.3	221	181.0	126.8	281	230.2	161.2
42	34.4	24.1	02	83.6	58.5	62	132.7	92.9	22	181.9	127.3	82	231.0	161.7
43	35.2	24.7	03	84.4	59.1	63	133.5	93.5	23	182.7	127.9	83	231.8	162.3
44	36.0	25.2	04	85.2	59.7	64	134.3	94.1	24	183.5	128.5	84	232.6	162.9
45	36.9	25.8	05	86.0	60.2	65	135.2	94.6	25	184.3	129.1	85	233.5	163.5
46	37.7	26.4	06	86.8	60.8	66	136.0	95.2	26	185.1	129.6	86	234.3	164.0
47	38.5	27.0	07	87.6	61.4	67	136.8	95.8	27	185.9	130.2	87	235.1	164.6
48	39.3	27.5	08	88.5	61.9	68	137.6	96.4	28	186.8	130.8	88	235.9	165.2
49	40.1	28.1	09	89.3	62.5	69	138.4	96.9	29	187.6	131.3	89	236.7	165.8
50	41.0	28.7	10	90.1	63.1	70	139.3	97.5	30	188.4	131.9	90	237.6	166.3
51	41.8	29.3	111	90.9	63.7	171	140.1	98.1	231	189.2	132.5	291	238.4	166.9
52	42.6	29.8	12	91.7	64.2	72	140.9	98.7	32	190.0	133.1	92	239.2	167.5
53	43.4	30.4	13	92.6	64.8	73	141.7	99.2	33	190.9	133.6	93	240.0	168.1
54	44.2	31.0	14	93.4	65.4	74	142.5	99.8	34	191.7	134.2	94	240.8	168.6
55	45.1	31.5	15	94.2	66.0	75	143.4	100.4	35	192.5	134.8	95	241.6	169.2
56	45.9	32.1	16	95.0	66.5	76	144.2	100.9	36	193.3	135.4	96	242.5	169.8
57	46.7	32.7	17	95.8	67.1	77	145.0	101.5	37	194.1	135.9	97	243.3	170.4
58	47.5	33.3	18	96.7	67.7	78	145.8	102.1	38	195.0	136.5	98	244.1	170.9
59	48.3	33.8	19	97.5	68.3	79	146.6	102.7	39	195.8	137.1	99	244.9	171 5
60	49.1	34.4	20	98.3	68.8	80	147.4	103.2	40	196.6	137.7	300	245.7	172.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 55 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 36 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	49.4	35.9	121	97.9	71.1	181	146.4	106.4	241	195.0	141.7
2	01.6	01.2	62	50.2	36.4	22	98.7	71.7	82	147.2	107.0	42	195.8	142.2
3	02.4	01.8	63	51.0	37.0	23	99.5	72.3	83	148.1	107.6	43	196.6	142.8
4	03.2	02.4	64	51.8	37.6	24	100.3	72.9	84	148.9	108.2	44	197.4	143.4
5	04.0	02.9	65	52.6	38.2	25	101.1	73.5	85	149.7	108.7	45	198.2	144.0
6	04.9	03.5	66	53.4	38.8	26	101.9	74.1	86	150.5	109.3	46	199.0	144.6
7	05.7	04.1	67	54.2	39.4	27	102.7	74.6	87	151.3	109.9	47	199.8	145.2
8	06.5	04.7	68	55.0	40.0	28	103.6	75.2	88	152.1	110.5	48	200.6	145.8
9	07.3	05.3	69	55.8	40.6	29	104.4	75.8	89	152.9	111.1	49	201.4	146.4
10	08.1	05.9	70	56.6	41.1	30	105.2	76.4	90	153.7	111.7	50	202.3	146.9
11	08.9	06.5	71	57.4	41.7	131	106.0	77.0	191	154.5	112.3	251	203.1	147.5
12	09.7	07.1	72	58.2	42.3	32	106.8	77.6	92	155.3	112.9	52	203.9	148.1
13	10.5	07.6	73	59.1	42.9	33	107.6	78.2	93	156.1	113.4	53	204.7	148.7
14	11.3	08.2	74	59.9	43.5	34	108.4	78.8	94	156.9	114.0	54	205.5	149.3
15	12.1	08.8	75	60.7	44.1	35	109.2	79.4	95	157.8	114.6	55	206.3	149.9
16	12.9	09.4	76	61.5	44.7	36	110.0	79.9	96	158.6	115.2	56	207.1	150.5
17	13.8	10.0	77	62.3	45.3	37	110.8	80.5	97	159.4	115.8	57	207.9	151.1
18	14.6	10.6	78	63.1	45.8	38	111.6	81.1	98	160.2	116.4	58	208.7	151.6
19	15.4	11.2	79	63.9	46.4	39	112.5	81.7	99	161.0	117.0	59	209.5	152.2
20	16.2	11.8	80	64.7	47.0	40	113.3	82.3	200	161.8	117.6	60	210.3	152.8
21	17.0	12.3	81	65.5	47.6	141	114.1	82.9	201	162.6	118.1	261	211.2	153.4
22	17.8	12.9	82	66.3	48.2	42	114.9	83.5	02	163.4	118.7	62	212.0	154.0
23	18.6	13.5	83	67.1	48.8	43	115.7	84.1	03	164.2	119.3	63	212.8	154.6
24	19.4	14.1	84	68.0	49.4	44	116.5	84.6	04	165.0	119.9	64	213.6	155.2
25	20.2	14.7	85	68.8	50.0	45	117.3	85.2	05	165.8	120.5	65	214.4	155.8
26	21.0	15.3	86	69.6	50.5	46	118.1	85.8	06	166.7	121.1	66	215.2	156.4
27	21.8	15.9	87	70.4	51.1	47	118.9	86.4	07	167.5	121.7	67	216.0	156.9
28	22.7	16.5	88	71.2	51.7	48	119.7	87.0	08	168.3	122.3	68	216.8	157.5
29	23.5	17.0	89	72.0	52.3	49	120.5	87.6	09	169.1	122.8	69	217.6	158.1
30	24.3	17.6	90	72.8	52.9	50	121.4	88.2	10	169.9	123.4	70	218.4	158.7
31	25.1	18.2	91	73.6	53.5	151	122.2	88.8	211	170.7	124.0	271	219.2	159.3
32	25.9	18.8	92	74.4	54.1	52	123.0	89.3	12	171.5	124.6	72	220.1	159.9
33	26.7	19.4	93	75.2	54.7	53	123.8	89.9	13	172.3	125.2	73	220.9	160.5
34	27.5	20.0	94	76.0	55.3	54	124.6	90.5	14	173.1	125.8	74	221.7	161.1
35	28.3	20.6	95	76.9	55.8	55	125.4	91.1	15	173.9	126.4	75	222.5	161.6
36	29.1	21.2	96	77.7	56.4	56	126.2	91.7	16	174.7	127.0	76	223.3	162.2
37	29.9	21.7	97	78.5	57.0	57	127.0	92.3	17	175.6	127.5	77	224.1	162.8
38	30.7	22.3	98	79.3	57.6	58	127.8	92.9	18	176.4	128.1	78	224.9	163.4
39	31.6	22.9	99	80.1	58.2	59	128.6	93.5	19	177.2	128.7	79	225.7	164.0
40	32.4	23.5	100	80.9	58.8	60	129.4	94.0	20	178.0	129.3	80	226.5	164.6
41	33.2	24.1	101	81.7	59.4	161	130.3	94.6	221	178.8	129.9	281	227.3	165.2
42	34.0	24.7	02	82.5	60.0	62	131.1	95.2	22	179.6	130.5	82	228.1	165.8
43	34.8	25.3	03	83.3	60.5	63	131.9	95.8	23	180.4	131.1	83	229.0	166.3
44	35.6	25.9	04	84.1	61.1	64	132.7	96.4	24	181.2	131.7	84	229.8	166.9
45	36.4	26.5	05	84.9	61.7	65	133.5	97.0	25	182.0	132.3	85	230.6	167.5
46	37.2	27.0	06	85.8	62.3	66	134.3	97.6	26	182.8	132.8	86	231.4	168.1
47	38.0	27.6	07	86.6	62.9	67	135.1	98.2	27	183.6	133.4	87	232.2	168.7
48	38.8	28.2	08	87.4	63.5	68	135.9	98.7	28	184.5	134.0	88	233.0	169.3
49	39.6	28.8	09	88.2	64.1	69	136.7	99.3	29	185.3	134.6	89	233.8	169.9
50	40.5	29.4	10	89.0	64.7	70	137.5	99.9	30	186.1	135.2	90	234.6	170.5
51	41.3	30.0	111	89.8	65.2	171	138.3	100.5	231	186.9	135.8	291	235.4	171.0
52	42.1	30.6	12	90.6	65.8	72	139.2	101.1	32	187.7	136.4	92	236.2	171.6
53	42.9	31.2	13	91.4	66.4	73	140.0	101.7	33	188.5	137.0	93	237.0	172.2
54	43.7	31.7	14	92.2	67.0	74	140.8	102.3	34	189.3	137.5	94	237.9	172.8
55	44.5	32.3	15	93.0	67.6	75	141.6	102.9	35	190.1	138.1	95	238.7	173.4
56	45.3	32.9	16	93.8	68.2	76	142.4	103.5	36	190.9	138.7	96	239.5	174.0
57	46.1	33.5	17	94.7	68.8	77	143.2	104.0	37	191.7	139.3	97	240.3	174.6
58	46.9	34.1	18	95.5	69.4	78	144.0	104.6	38	192.5	139.9	98	241.1	175.2
59	47.7	34.7	19	96.3	69.9	79	144.8	105.2	39	193.4	140.5	99	241.9	175.7
60	48.5	35.3	20	97.1	70.5	80	145.6	105.8	40	194.2	141.1	300	242.7	176.3
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 54 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 37 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	48.7	36.7	121	96.6	72.8	181	144.6	108.9	241	192.5	145.0
2	01.6	01.2	62	49.5	37.3	22	97.4	73.4	82	145.4	109.5	42	193.3	145.6
3	02.4	01.8	63	50.3	37.9	23	98.2	74.0	83	146.2	110.1	43	194.1	146.2
4	03.2	02.4	64	51.1	38.5	24	99.0	74.6	84	146.9	110.7	44	194.9	146.8
5	04.0	03.0	65	51.9	39.1	25	99.8	75.2	85	147.7	111.3	45	195.7	147.4
6	04.8	03.6	66	52.7	39.7	26	100.6	75.8	86	148.5	111.9	46	196.5	148.0
7	05.6	04.2	67	53.5	40.3	27	101.4	76.4	87	149.3	112.5	47	197.3	148.6
8	06.4	04.8	68	54.3	40.9	28	102.2	77.0	88	150.1	113.1	48	198.1	149.3
9	07.2	05.4	69	55.1	41.5	29	103.0	77.6	89	150.9	113.7	49	198.9	149.9
10	08.0	06.0	70	55.9	42.1	30	103.8	78.2	90	151.7	114.3	50	199.7	150.5
11	08.8	06.6	71	56.7	42.7	131	104.6	78.8	191	152.5	114.9	251	200.5	151.1
12	09.6	07.2	72	57.5	43.3	32	105.4	79.4	92	153.3	115.5	52	201.3	151.7
13	10.4	07.8	73	58.3	43.9	33	106.2	80.0	93	154.1	116.2	53	202.1	152.3
14	11.2	08.4	74	59.1	44.5	34	107.0	80.6	94	154.9	116.8	54	202.9	152.9
15	12.0	09.0	75	59.9	45.1	35	107.8	81.2	95	155.7	117.4	55	203.7	153.5
16	12.8	09.6	76	60.7	45.7	36	108.6	81.8	96	156.5	118.0	56	204.5	154.1
17	13.6	10.2	77	61.5	46.3	37	109.4	82.4	97	157.3	118.6	57	205.2	154.7
18	14.4	10.8	78	62.3	46.9	38	110.2	83.1	98	158.1	119.2	58	206.0	155.3
19	15.2	11.4	79	63.1	47.5	39	111.0	83.7	99	158.9	119.8	59	206.8	155.9
20	16.0	12.0	80	63.9	48.1	40	111.8	84.3	200	159.7	120.4	60	207.6	156.5
21	16.8	12.6	81	64.7	48.7	141	112.6	84.9	201	160.5	121.0	261	208.4	157.1
22	17.6	13.2	82	65.5	49.3	42	113.4	85.5	02	161.3	121.6	62	209.2	157.7
23	18.4	13.8	83	66.3	50.0	43	114.2	86.1	03	162.1	122.2	63	210.0	158.3
24	19.2	14.4	84	67.1	50.6	44	115.0	86.7	04	162.9	122.8	64	210.8	158.9
25	20.0	15.0	85	67.9	51.2	45	115.8	87.3	05	163.7	123.4	65	211.6	159.5
26	20.8	15.6	86	68.7	51.8	46	116.6	87.9	06	164.5	124.0	66	212.4	160.1
27	21.6	16.2	87	69.5	52.4	47	117.4	88.5	07	165.3	124.6	67	213.2	160.7
28	22.4	16.9	88	70.3	53.0	48	118.2	89.1	08	166.1	125.2	68	214.0	161.3
29	23.2	17.5	89	71.1	53.6	49	119.0	89.7	09	166.9	125.8	69	214.8	161.9
30	24.0	18.1	90	71.9	54.2	50	119.8	90.3	10	167.7	126.4	70	215.6	162.5
31	24.8	18.7	91	72.7	54.8	151	120.6	90.9	211	168.5	127.0	271	216.4	163.1
32	25.6	19.3	92	73.5	55.4	52	121.4	91.5	12	169.3	127.6	72	217.2	163.7
33	26.4	19.9	93	74.3	56.0	53	122.2	92.1	13	170.1	128.2	73	218.0	164.3
34	27.2	20.5	94	75.1	56.6	54	123.0	92.7	14	170.9	128.8	74	218.8	164.9
35	28.0	21.1	95	75.9	57.2	55	123.8	93.3	15	171.7	129.4	75	219.6	165.5
36	28.8	21.7	96	76.7	57.8	56	124.6	93.9	16	172.5	130.0	76	220.4	166.1
37	29.5	22.3	97	77.5	58.4	57	125.4	94.5	17	173.3	130.6	77	221.2	166.7
38	30.3	22.9	98	78.3	59.0	58	126.2	95.1	18	174.1	131.2	78	222.0	167.3
39	31.1	23.5	99	79.1	59.6	59	127.0	95.7	19	174.9	131.8	79	222.8	167.9
40	31.9	24.1	100	79.9	60.2	60	127.8	96.3	20	175.7	132.4	80	223.6	168.5
41	32.7	24.7	101	80.7	60.8	161	128.6	96.9	221	176.5	133.0	281	224.4	169.1
42	33.5	25.3	02	81.5	61.4	62	129.4	97.5	22	177.3	133.6	82	225.2	169.7
43	34.3	25.9	03	82.3	62.0	63	130.2	98.1	23	178.1	134.2	83	226.0	170.3
44	35.1	26.5	04	83.1	62.6	64	131.0	98.7	24	178.9	134.8	84	226.8	170.9
45	35.9	27.1	05	83.9	63.2	65	131.8	99.3	25	179.7	135.4	85	227.6	171.5
46	36.7	27.7	06	84.7	63.8	66	132.6	99.9	26	180.5	136.0	86	228.4	172.1
47	37.5	28.3	07	85.5	64.4	67	133.4	100.5	27	181.3	136.6	87	229.2	172.7
48	38.3	28.9	08	86.3	65.0	68	134.2	101.1	28	182.1	137.2	88	230.0	173.3
49	39.1	29.5	09	87.1	65.6	69	135.0	101.7	29	182.9	137.8	89	230.8	173.9
50	39.9	30.1	10	87.8	66.2	70	135.8	102.3	30	183.7	138.4	90	231.6	174.5
51	40.7	30.7	111	88.6	66.8	171	136.6	102.9	231	184.5	139.0	291	232.4	175.1
52	41.5	31.3	12	89.4	67.4	72	137.4	103.5	32	185.3	139.6	92	233.2	175.7
53	42.3	31.9	13	90.2	68.0	73	138.2	104.1	33	186.1	140.2	93	234.0	176.3
54	43.1	32.5	14	91.0	68.6	74	139.0	104.7	34	186.9	140.8	94	234.8	176.9
55	43.9	33.1	15	91.8	69.2	75	139.8	105.3	35	187.7	141.4	95	235.6	177.5
56	44.7	33.7	16	92.6	69.8	76	140.6	105.9	36	188.5	142.0	96	236.4	178.1
57	45.5	34.3	17	93.4	70.4	77	141.4	106.5	37	189.3	142.6	97	237.2	178.7
58	46.3	34.9	18	94.2	71.0	78	142.2	107.1	38	190.1	143.2	98	238.0	179.3
59	47.1	35.5	19	95.0	71.6	79	143.0	107.7	39	190.9	143.8	99	238.8	179.9
60	47.9	36.1	20	95.8	72.2	80	143.8	108.3	40	191.7	144.4	300	239.6	180.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 38 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep
1	00.8	00.6	61	48.1	37.6	121	95.3	74.5	181	142.6	111.4	241	189.9	148.4
2	01.6	01.2	62	48.9	38.2	22	96.1	75.1	82	143.4	112.1	42	190.7	149.0
3	02.4	01.8	63	49.6	38.8	23	96.9	75.7	83	144.2	112.7	43	191 5	149.6
4	03.2	02.5	64	50.4	39.4	24	97.7	76.3	84	145.0	113.3	44	192.3	150.2
5	03.9	03.1	65	51.2	40.0	25	98.5	77.0	85	145.8	113.9	45	193.1	150.8
6	04.7	03.7	66	52.0	40.6	26	99.3	77.6	86	146.6	114.5	46	193.9	151.5
7	05.5	04.3	67	52.8	41.2	27	100.1	78.2	87	147.4	115.1	47	194.6	152.1
8	06.3	04.9	68	53.6	41.9	28	100.9	78.8	88	148.1	115.7	48	195.4	152.7
9	07.1	05.5	69	54.4	42.5	29	101.7	79.4	89	148.9	116.4	49	196.2	153.3
10	07.9	06.2	70	55.2	43.1	30	102.4	80.0	90	149.7	117.0	50	197.0	153.9
11	08.7	06.8	71	55.9	43.7	131	103.2	80.7	191	150.5	117.6	251	197.8	154.5
12	09.5	07.4	72	56.7	44.3	32	104.0	81.3	92	151.3	118.2	52	198.6	155.1
13	10.2	08.0	73	57.5	44.9	33	104.8	81.9	93	152.1	118.8	53	199.4	155.8
14	11.0	08.6	74	58.3	45.6	34	105.6	82.5	94	152.9	119.4	54	200.2	156.4
15	11.8	09.2	75	59.1	46.2	35	106.4	83.1	95	153.7	120.1	55	200.9	157.0
16	12.6	09.9	76	59.9	46.8	36	107.2	83.7	96	154.5	120.7	56	201.7	157.6
17	13.4	10.5	77	60.7	47.4	37	108.0	84.3	97	155.2	121.3	57	202.5	158.2
18	14.2	11.1	78	61.5	48.0	38	108.7	85.0	98	156.0	121.9	58	203.3	158.8
19	15.0	11.7	79	62.3	48.6	39	109.5	85.6	99	156.8	122.5	59	204.1	159.5
20	15.8	12.3	80	63.0	49.3	40	110.3	86.2	200	157.6	123.1	60	204.9	160.1
21	16.5	12.9	81	63.8	49.9	141	111.1	86.8	201	158.4	123.7	261	205.7	160.7
22	17.3	13.5	82	64.6	50.5	42	111.9	87.4	02	159.2	124.4	62	206.5	161.3
23	18.1	14.2	83	65.4	51.1	43	112.7	88.0	03	160.0	125.0	63	207.2	161.9
24	18.9	14.8	84	66.2	51.7	44	113.5	88.7	04	160.8	125.6	64	208.0	162.5
25	19.7	15.4	85	67.0	52.3	45	114.3	89.3	05	161.5	126.2	65	208.8	163.2
26	20.5	16.0	86	67.8	52.9	46	115.0	89.9	06	162.3	126.8	66	209.6	163.8
27	21.3	16.6	87	68.6	53.6	47	115.8	90.5	07	163.1	127.4	67	210.4	164.4
28	22.1	17.2	88	69.3	54.2	48	116.6	91.1	08	163.9	128.1	68	211.2	165.0
29	22.9	17.9	89	70.1	54.8	49	117.4	91.7	09	164.7	128.7	69	212.0	165.6
30	23.6	18.5	90	70.9	55.4	50	118.2	92.3	10	165.5	129.3	70	212.8	166.2
31	24.4	19.1	91	71.7	56.0	151	119.0	93.0	211	166.3	129.9	271	213.6	166.8
32	25.2	19.7	92	72.5	56.6	52	119.8	93.6	12	167.1	130.5	72	214.3	167.5
33	26.0	20.3	93	73.3	57.3	53	120.6	94.2	13	167.8	131.1	73	215.1	168.1
34	26.8	20.9	94	74.1	57.9	54	121.4	94.8	14	168.6	131.8	74	215.9	168.7
35	27.6	21.5	95	74.9	58.5	55	122.1	95.4	15	169.4	132.4	75	216.7	169.3
36	28.4	22.2	96	75.6	59.1	56	122.9	96.0	16	170.2	133.0	76	217.5	169.9
37	29.2	22.8	97	76.4	59.7	57	123.7	96.7	17	171.0	133.6	77	218.3	170.5
38	29.9	23.4	98	77.2	60.3	58	124.5	97.3	18	171.8	134.2	78	219.1	171.2
39	30.7	24.0	99	78.0	61.0	59	125.3	97.9	19	172.6	134.8	79	219.9	171.8
40	31.5	24.6	100	78.8	61.6	60	126.1	98.5	20	173.4	135.4	80	220.6	172.4
41	32.3	25.2	101	79.6	62.2	161	126.9	99.1	221	174.2	136.1	281	221.4	173.0
42	33.1	25.9	02	80.4	62.8	62	127.7	99.7	22	174.9	136.7	82	222.2	173.6
43	33.9	26.5	03	81.2	63.4	63	128.4	100.4	23	175.7	137.3	83	223.0	174.2
44	34.7	27.1	04	82.0	64.0	64	129.2	101.0	24	176.5	137.9	84	223.8	174.8
45	35.5	27.7	05	82.7	64.6	65	130.0	101.6	25	177.3	138.5	85	224.6	175.5
46	36.2	28.3	06	83.5	65.3	66	130.8	102.2	26	178.1	139.1	86	225.4	176.1
47	37.0	28.9	07	84.3	65.9	67	131.6	102.8	27	178.9	139.8	87	226.2	176.7
48	37.8	29.6	08	85.1	66.5	68	132.4	103.4	28	179.7	140.4	88	226.9	177.3
49	38.6	30.2	09	85.9	67.1	69	133.2	104.0	29	180.5	141.0	89	227.7	177 9
50	39.4	30.8	10	86.7	67.7	70	134.0	104.7	30	181.2	141.6	90	228.5	178.5
51	40.2	31.4	111	87.5	68.3	171	134.7	105.3	231	182.0	142.2	291	229.3	179.2
52	41.0	32.0	12	88.3	69.0	72	135.5	105.9	32	182.8	142.8	92	230.1	179.8
53	41.8	32.6	13	89.0	69.6	73	136.3	106.5	33	183.6	143.4	93	230.9	180.4
54	42.6	33.2	14	89.8	70.2	74	137.1	107.1	34	184.4	144.1	94	231.7	181.0
55	43.3	33.9	15	90.6	70.8	75	137.9	107.7	35	185.2	144.7	95	232.5	181.6
56	44.1	34.5	16	91.4	71.4	76	138.7	108.4	36	186.0	145.3	96	233.3	182.2
57	44.9	35.1	17	92.2	72.0	77	139.5	109.0	37	186.8	145.9	97	234.0	182.9
58	45.7	35.7	18	93.0	72 6	78	140.3	109.6	38	187.5	146.5	98	234.8	183.5
59	46.5	36.3	19	93.8	73 3	79	141.1	110.2	39	188.3	147.1	99	235.6	184.1
60	47.3	36.9	20	94.6	73 9	80	141.8	110.8	40	189.1	147.8	300	236.4	184.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 52 Degrees.

TABLE II.

Difference of Latitude and Departure for 39 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	47.4	38.4	121	94.0	76.1	181	140.7	113.9	241	187.3	151.7
2	01.6	01.3	62	48.2	39.0	22	94.8	76.8	82	141.4	114.5	42	188.1	152.3
3	02.3	01.9	63	49.0	39.6	23	95.6	77.4	83	142.2	115.2	43	188.8	152.9
4	03.1	02.5	64	49.7	40.3	24	96.4	78.0	84	143.0	115.8	44	189.6	153.6
5	03.9	03.1	65	50.5	40.9	25	97.1	78.7	85	143.8	116.4	45	190.4	154.2
6	04.7	03.8	66	51.3	41.5	26	97.9	79.3	86	144.5	117.1	46	191.2	154.8
7	05.4	04.4	67	52.1	42.2	27	98.7	79.9	87	145.3	117.7	47	192.0	155.4
8	06.2	05.0	68	52.8	42.8	28	99.5	80.6	88	146.1	118.3	48	192.7	156.1
9	07.0	05.7	69	53.6	43.4	29	100.3	81.2	89	146.9	118.9	49	193.5	156.7
10	07.8	06.3	70	54.4	44.1	30	101.0	81.8	90	147.7	119.6	50	194.3	157.3
11	08.5	06.9	71	55.2	44.7	131	101.8	82.4	191	148.4	120.2	251	195.1	158.0
12	09.3	07.6	72	56.0	45.3	32	102.6	83.1	92	149.2	120.8	52	195.8	158.6
13	10.1	08.2	73	56.7	45.9	33	103.4	83.7	93	150.0	121.5	53	196.6	159.2
14	10.9	08.8	74	57.5	46.6	34	104.1	84.3	94	150.8	122.1	54	197.4	159.8
15	11.7	09.4	75	58.3	47.2	35	104.9	85.0	95	151.5	122.7	55	198.2	160.5
16	12.4	10.1	76	59.1	47.8	36	105.7	85.6	96	152.3	123.3	56	198.9	161.1
17	13.2	10.7	77	59.8	48.5	37	106.5	86.2	97	153.1	124.0	57	199.7	161.7
18	14.0	11.3	78	60.6	49.1	38	107.2	86.8	98	153.9	124.6	58	200.5	162.4
19	14.8	12.0	79	61.4	49.7	39	108.0	87.5	99	154.7	125.2	59	201.3	163.0
20	15.5	12.6	80	62.2	50.3	40	108.8	88.1	200	155.4	125.9	60	202.1	163.6
21	16.3	13.2	81	62.9	51.0	141	109.6	88.7	201	156.2	126.5	261	202.8	164.3
22	17.1	13.8	82	63.7	51.6	42	110.4	89.4	02	157.0	127.1	62	203.6	164.9
23	17.9	14.5	83	64.5	52.2	43	111.1	90.0	03	157.8	127.8	63	204.4	165.5
24	18.7	15.1	84	65.3	52.9	44	111.9	90.6	04	158.5	128.4	64	205.2	166.1
25	19.4	15.7	85	66.1	53.5	45	112.7	91.3	05	159.3	129.0	65	205.9	166.8
26	20.2	16.4	86	66.8	54.1	46	113.5	91.9	06	160.1	129.6	66	206.7	167.4
27	21.0	17.0	87	67.6	54.8	47	114.2	92.5	07	160.9	130.3	67	207.5	168.0
28	21.8	17.6	88	68.4	55.4	48	115.0	93.1	08	161.6	130.9	68	208.3	168.7
29	22.5	18.3	89	69.2	56.0	49	115.8	93.8	09	162.4	131.5	69	209.1	169.3
30	23.3	18.9	90	69.9	56.6	50	116.6	94.4	10	163.2	132.2	70	209.8	169.9
31	24.1	19.5	91	70.7	57.3	151	117.3	95.0	211	164.0	132.8	271	210.6	170.5
32	24.9	20.1	92	71.5	57.9	52	118.1	95.7	12	164.8	133.4	72	211.4	171.2
33	25.6	20.8	93	72.3	58.5	53	118.9	96.3	13	165.5	134.0	73	212.2	171.8
34	26.4	21.4	94	73.1	59.2	54	119.7	96.9	14	166.3	134.7	74	212.9	172.4
35	27.2	22.0	95	73.8	59.8	55	120.5	97.5	15	167.1	135.3	75	213.7	173.1
36	28.0	22.7	96	74.6	60.4	56	121.2	98.2	16	167.9	135.9	76	214.5	173.7
37	28.8	23.3	97	75.4	61.0	57	122.0	98.8	17	168.6	136.6	77	215.3	174.3
38	29.5	23.9	98	76.2	61 7	58	122.8	99.4	18	169.4	137.2	78	216.0	175.0
39	30.3	24.5	99	76.9	62.3	59	123.6	100.1	19	170.2	137.8	79	216.8	175.6
40	31.1	25.2	100	77.7	62.9	60	124.3	100.7	20	171.0	138.5	80	217.6	176.2
41	31.9	25.8	101	78.5	63.6	161	125.1	101.3	221	171.7	139.1	281	218.4	176.8
42	32.6	26.4	02	79.3	64.2	62	125.9	101.9	22	172.5	139.7	82	219.2	177.5
43	33.4	27.1	03	80.0	64.8	63	126.7	102.6	23	173.3	140.3	83	219.9	178.1
44	34.2	27.7	04	80.8	65.4	64	127.5	103.2	24	174.1	141.0	84	220.7	178.7
45	35.0	28.3	05	81.6	66.1	65	128.2	103.8	25	174.9	141.6	85	221.5	179.4
46	35.7	28.9	06	82.4	66.7	66	129.0	104.5	26	175.6	142.2	86	222.3	180.0
47	36.5	29.6	07	83.2	67.3	67	129.8	105.1	27	176.4	142.9	87	223.0	180.6
48	37.3	30.2	08	83.9	68.0	68	130.6	105.7	28	177.2	143.5	88	223.8	181.2
49	38.1	30.8	09	84.7	68.6	69	131.3	106 4	29	178.0	144.1	89	224.6	181.9
50	38.9	31.5	10	85.5	69.2	70	132.1	107.0	30	178.7	144.7	90	225.4	182.5
51	39.6	32.1	111	86.3	69.9	171	132.9	107.6	231	179.5	145.4	291	226.1	183.1
52	40.4	32.7	12	87.0	70.5	72	133.7	108.2	32	180.3	146.0	92	226.9	183.8
53	41.2	33.4	:3	87.8	71.1	73	134.4	108.9	33	181.1	146.6	93	227.7	184.4
54	42.0	34.0	14	88.6	71.7	74	135.2	109.5	34	181.9	147.3	94	228.5	185.0
55	42.7	34.6	15	89.4	72.4	75	136.0	110.1	35	182.6	147.9	95	229.3	185.6
56	43.5	35.2	16	90.1	73.0	76	136.8	110.8	36	183.4	148.5	96	230.0	186.3
57	44.3	35.9	17	90.9	73.6	77	137.6	111.4	37	184.2	149.1	97	230.8	186.9
58	45.1	36.5	18	91.7	74.3	78	138.3	112.0	38	185.0	149.8	98	231.6	187.5
59	45.9	37.1	19	92.5	74.9	79	139.1	112.6	39	185.7	150.4	99	232.4	188.2
60	45.6	37.8	20	93.3	75.5	80	139.9	113.3	40	186.5	151.0	300	233.1	188.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 51 Degrees

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 40 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	46.7	39.2	121	92.7	77.8	181	138.7	116.3	241	184.6	154.9
2	01.5	01.3	62	47.5	39.9	22	93.5	78.4	82	139.4	117.0	42	185.4	155.6
3	02.3	01.9	63	48.3	40.5	23	94.2	79.1	83	140.2	117.6	43	186.1	156.2
4	03.1	02.6	64	49.0	41.1	24	95.0	79.7	84	141.0	118.3	44	186.9	156.8
5	03.8	03.2	65	49.8	41.8	25	95.8	80.3	85	141.7	118.9	45	187.7	157.5
6	04.6	03.9	66	50.6	42.4	26	96.5	81.0	86	142.5	119.6	46	188.4	158.1
7	05.4	04.5	67	51.3	43.1	27	97.3	81.6	87	143.3	120.2	47	189.2	158.8
8	06.1	05.1	68	52.1	43.7	28	98.1	82.3	88	144.0	120.8	48	190.0	159.4
9	06.9	05.8	69	52.9	44.4	29	98.8	82.9	89	144.8	121.5	49	190.7	160.1
10	07.7	06.4	70	53.6	45.0	30	99.6	83.6	90	145.5	122.1	50	191.5	160.7
11	08.4	07.1	71	54.4	45.6	131	100.4	84.2	191	146.3	122.8	251	192.3	161.3
12	09.2	07.7	72	55.2	46.3	32	101.1	84.8	92	147.1	123.4	52	193.0	162.0
13	10.0	08.4	73	55.9	46.9	33	101.9	85.5	93	147.8	124.1	53	193.8	162.6
14	10.7	09.0	74	56.7	47.6	34	102.6	86.1	94	148.6	124.7	54	194.6	163.3
15	11.5	09.6	75	57.5	48.2	35	103.4	86.8	95	149.4	125.3	55	195.3	163.9
16	12.3	10.3	76	58.2	48.9	36	104.2	87.4	96	150.1	126.0	56	196.1	164.6
17	13.0	10.9	77	59.0	49.5	37	104.9	88.1	97	150.9	126.6	57	196.9	165.2
18	13.8	11.6	78	59.8	50.1	38	105.7	88.7	98	151.7	127.3	58	197.6	165.8
19	14.6	12.2	79	60.5	50.8	39	106.5	89.3	99	152.4	127.9	59	198.4	166.5
20	15.3	12.9	80	61.3	51.4	40	107.2	90.0	200	153.2	128.6	60	199.2	167.1
21	16.1	13.5	81	62.0	52.1	141	108.0	90.6	201	154.0	129.2	261	199.9	167.8
22	16.9	14.1	82	62.8	52.7	42	108.8	91.3	02	154.7	129.8	62	200.7	168.4
23	17.6	14.8	83	63.6	53.4	43	109.5	91.9	03	155.5	130.5	63	201.5	169.1
24	18.4	15.4	84	64.3	54.0	44	110.3	92.6	04	156.3	131.1	64	202.2	169.7
25	19.2	16.1	85	65.1	54.6	45	111.1	93.2	05	157.0	131.8	65	203.0	170.3
26	19.9	16.7	86	65.9	55.3	46	111.8	93.8	06	157.8	132.4	66	203.8	171.0
27	20.7	17.4	87	66.6	55.9	47	112.6	94.5	07	158.6	133.1	67	204.5	171.6
28	21.4	18.0	88	67.4	56.6	48	113.4	95.1	08	159.3	133.7	68	205.3	172.3
29	22.2	18.6	89	68.2	57.2	49	114.1	95.8	09	160.1	134.3	69	206.1	172.9
30	23.0	19.3	90	68.9	57.9	50	114.9	96.4	10	160.9	135.0	70	206.8	173.6
31	23.7	19.9	91	69.7	58.5	151	115.7	97.1	211	161.6	135.6	271	207.6	174.2
32	24.5	20.6	92	70.5	59.1	52	116.4	97.7	12	162.4	136.3	72	208.4	174.8
33	25.3	21.2	93	71.2	59.8	53	117.2	98.3	13	163.2	136.9	73	209.1	175.5
34	26.0	21.9	94	72.0	60.4	54	118.0	99.0	14	163.9	137.6	74	209.9	176.1
35	26.8	22.5	95	72.8	61.1	55	118.7	99.6	15	164.7	138.2	75	210.7	176.8
36	27.6	23.1	96	73.5	61.7	56	119.5	100.3	16	165.5	138.8	76	211.4	177.4
37	28.3	23.8	97	74.3	62.4	57	120.3	100.9	17	166.2	139.5	77	212.2	178.1
38	29.1	24.4	98	75.1	63.0	58	121.0	101.6	18	167.0	140.1	78	213.0	178.7
39	29.9	25.1	99	75.8	63.6	59	121.8	102.2	19	167.8	140.8	79	213.7	179.3
40	30.6	25.7	100	76.6	64.3	60	122.6	102.8	20	168.5	141.4	80	214.5	180.0
41	31.4	26.4	101	77.4	64.9	161	123.3	103.5	221	169.3	142.1	281	215.3	180.6
42	32.2	27.0	02	78.1	65.6	62	124.1	104.1	22	170.1	142.7	82	216.0	181.3
43	32.9	27.6	03	78.9	66.2	63	124.9	104.8	23	170.8	143.3	83	216.8	181.9
44	33.7	28.3	04	79.7	66.8	64	125.6	105.4	24	171.6	144.0	84	217.6	182.6
45	34.5	28.9	05	80.4	67.5	65	126.4	106.1	25	172.4	144.6	85	218.3	183.2
46	35.2	29.6	06	81.2	68.1	66	127.2	106.7	26	173.1	145.3	86	219.1	183.8
47	36.0	30.2	07	82.0	68.8	67	127.9	107.3	27	173.9	145.9	87	219.9	184.5
48	36.8	30.9	08	82.7	69.4	68	128.7	108.0	28	174.7	146.6	88	220.6	185.1
49	37.5	31.5	09	83.5	70.1	69	129.5	108.6	29	175.4	147.2	89	221.4	185.8
50	38.3	32.1	10	84.3	70.7	70	130.2	109.3	30	176.2	147.8	90	222.2	186.4
51	39.1	32.8	111	85.0	71.3	171	131.0	109.9	231	177.0	148.5	291	222.9	187.1
52	39.8	33.4	12	85.8	72.0	72	131.8	110.6	32	177.7	149.1	92	223.7	187.7
53	40.6	34.1	13	86.6	72.6	73	132.5	111.2	33	178.5	149.8	93	224.5	188.3
54	41.4	34.7	14	87.3	73.3	74	133.3	111.8	34	179.3	150.4	94	225.2	189.0
55	42.1	35.4	15	88.1	73.9	75	134.1	112.5	35	180.0	151.1	95	226.0	189.6
56	42.9	36.0	16	88.9	74.6	76	134.8	113.1	36	180.8	151.7	96	226.7	190.3
57	43.7	36.6	17	89.6	75.2	77	135.6	113.8	37	181.6	152.3	97	227.5	190.9
58	44.4	37.3	18	90.4	75.8	78	136.4	114.4	38	182.3	153.0	98	228.3	191.6
59	45.2	37.9	19	91.2	76.5	79	137.1	115.1	39	183.1	153.6	99	229.0	192.2
60	46.0	38.6	20	91.9	77.1	80	137.9	115.7	40	183.9	154.3	300	229.8	192.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 50 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 41 Degrees

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.7	61	46.0	40.0	121	91.3	79.4	181	136.6	118.7	241	181.9	158.1
2	01.5	01.3	62	46.8	40.7	22	92.1	80.0	82	137.4	119.4	42	182.6	158.8
3	02.3	02.0	63	47.5	41.3	23	92.8	80.7	83	138.1	120.1	43	183.4	159.4
4	03.0	02.6	64	48.3	42.0	24	93.6	81.4	84	138.9	120.7	44	184.1	160.1
5	03.8	03.3	65	49.1	42.6	25	94.3	82.0	85	139.6	121.4	45	184.9	160.7
6	04.5	03.9	66	49.8	43.3	26	95.1	82.7	86	140.4	122.0	46	185.7	161.4
7	05.3	04.6	67	50.6	44.0	27	95.8	83.3	87	141.1	122.7	47	186.4	162.0
8	06.0	05.2	68	51.3	44.6	28	96.6	84.0	88	141.9	123.3	48	187.2	162.7
9	06.8	05.9	69	52.1	45.3	29	97.4	84.6	89	142.6	124.0	49	187.9	163.4
10	07.5	06.6	70	52.8	45.9	30	98.1	85.3	90	143.4	124.7	50	188.7	164.0
11	08.3	07.2	71	53.6	46.6	131	98.9	85.9	191	144.1	125.3	251	189.4	164.7
12	09.1	07.9	72	54.3	47.2	32	99.6	86.6	92	144.9	126.0	52	190.2	165.3
13	09.8	08.5	73	55.1	47.9	33	100.4	87.3	93	145.7	126.6	53	190.9	166.0
14	10.6	09.2	74	55.8	48.5	34	101.1	87.9	94	146.4	127.3	54	191.7	166.6
15	11.3	09.8	75	56.6	49.2	35	101.9	88.6	95	147.2	127.9	55	192.5	167.3
16	12.1	10.5	76	57.4	49.9	36	102.6	89.2	96	147.9	128.6	56	193.2	168.0
17	12.8	11.2	77	58.1	50.5	37	103.4	89.9	97	148.7	129.2	57	194.0	168.6
18	13.6	11.8	78	58.9	51.2	38	104.1	90.5	98	149.4	129.9	58	194.7	169.3
19	14.3	12.5	79	59.6	51.8	39	104.9	91.2	99	150.2	130.6	59	195.5	169.9
20	15.1	13.1	80	60.4	52.5	40	105.7	91.8	200	150.9	131.2	60	196.2	170.6
21	15.8	13.8	81	61.1	53.1	141	106.4	92.5	201	151.7	131.9	261	197.0	171.2
22	16.6	14.4	82	61.9	53.8	42	107.2	93.2	02	152.5	132.5	62	197.7	171.9
23	17.4	15.1	83	62.6	54.5	43	107.9	93.8	03	153.2	133.2	63	198.5	172.5
24	18.1	15.7	84	63.4	55.1	44	108.7	94.5	04	154.0	133.8	64	199.2	173.2
25	18.9	16.4	85	64.2	55.8	45	109.4	95.1	05	154.7	134.5	65	200.0	173.9
26	19.6	17.1	86	64.9	56.4	46	110.2	95.8	06	155.5	135.1	66	200.8	174.5
27	20.4	17.7	87	65.7	57.1	47	110.9	96.4	07	156.2	135.8	67	201.5	175.2
28	21.1	18.4	88	66.4	57.7	48	111.7	97.1	08	157.0	136.5	68	202.3	175.8
29	21.9	19.0	89	67.2	58.4	49	112.5	97.8	09	157.7	137.1	69	203.0	176.5
30	22.6	19.7	90	67.9	59.0	50	113.2	98.4	10	158.5	137.8	70	203.8	177.1
31	23.4	20.3	91	68.7	59.7	151	114.0	99.1	211	159.2	138.4	271	204.5	177.8
32	24.2	21.0	92	69.4	60.4	52	114.7	99.7	12	160.0	139.1	72	205.3	178.4
33	24.9	21.6	93	70.2	61.0	53	115.5	100.4	13	160.8	139.7	73	206.0	179.1
34	25.7	22.3	94	70.9	61.7	54	116.2	101.0	14	161.5	140.4	74	206.8	179.8
35	26.4	23.0	95	71.7	62.3	55	117.0	101.7	15	162.3	141.1	75	207.5	180.4
36	27.2	23.6	96	72.5	63.0	56	117.7	102.3	16	163.0	141.7	76	208.3	181.1
37	27.9	24.3	97	73.2	63.6	57	118.5	103.0	17	163.8	142.4	77	209.1	181.7
38	28.7	24.9	98	74.0	64.3	58	119.2	103.7	18	164.5	143.0	78	209.8	182.4
39	29.4	25.6	99	74.7	64.9	59	120.0	104.3	19	165.3	143.7	79	210.6	183.0
40	30.2	26.2	100	75.5	65.6	60	120.8	105.0	20	166.0	144.3	80	211.3	183.7
41	30.9	26.9	101	76.2	66.3	161	121.5	105.6	221	166.8	145.0	281	212.1	184.4
42	31.7	27.6	02	77.0	66.9	62	122.3	106.3	22	167.5	145.6	82	212.8	185.0
43	32.5	28.2	03	77.7	67.6	63	123.0	106.9	23	168.3	146.3	83	213.6	185.7
44	33.2	28.9	04	78.5	68.2	64	123.8	107.6	24	169.1	147.0	84	214.3	186.3
45	34.0	29.5	05	79.2	68.9	65	124.5	108.2	25	169.8	147.6	85	215.1	187.0
46	34.7	30.2	06	80.0	69.5	66	125.3	108.9	26	170.6	148.3	86	215.8	187.6
47	35.5	30.8	07	80.8	70.2	67	126.0	109.6	27	171.3	148.9	87	216.6	188.3
48	36.2	31.5	08	81.5	70.9	68	126.8	110.2	28	172.1	149.6	88	217.4	188.9
49	37.0	32.1	09	82.3	71.5	69	127.5	110.9	29	172.8	150.2	89	218.1	189.6
50	37.7	32.8	10	83.0	72.2	70	128.3	111.5	30	173.6	150.9	90	218.9	190.3
51	38.5	33.5	111	83.8	72.8	171	129.1	112.2	231	174.3	151.5	291	219.6	190.9
52	39.2	34.1	12	84.5	73.5	72	129.8	112.8	32	175.1	152.2	92	220.4	191.6
53	40.0	34.8	13	85.3	74.1	73	130.6	113.5	33	175.8	152.9	93	221.1	192.2
54	40.8	35.4	14	86.0	74.8	74	131.3	114.2	34	176.6	153.5	94	221.9	192.9
55	41.5	36.1	15	86.8	75.4	75	132.1	114.8	35	177.4	154.2	95	222.6	193.5
56	42.3	36.7	16	87.5	76.1	76	132.8	115.5	36	178.1	154.8	96	223.4	194.2
57	43.0	37.4	17	88.3	76.8	77	133.6	116.1	37	178.9	155.5	97	224.1	194.8
58	43.8	38.1	18	89.1	77.4	78	134.3	116.8	38	179.6	156.1	98	224.9	195.5
59	44.5	38.7	19	89.8	78.1	79	135.1	117.4	39	180.4	156.8	99	225.7	196.2
60	45.3	39.4	20	90.6	78.7	80	135.8	118.1	40	181.1	157.5	300	226.4	196.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 49 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 42 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.7	00.7	61	45.3	40.8	121	89.9	81.0	181	134.5	121.1	241	179.1	161.3
2	01.5	01.3	62	46.1	41.5	22	90.7	81.6	82	135.3	121.8	42	179.8	161.9
3	02.2	02.0	63	46.8	42.2	23	91.4	82.3	83	136.0	122.5	43	180.6	162.6
4	03.0	02.7	64	47.6	42.8	24	92.1	83.0	84	136.7	123.1	44	181.3	163.3
5	03.7	03.3	65	48.3	43.5	25	92.9	83.6	85	137.5	123.8	45	182.1	163.9
6	04.5	04.0	66	49.0	44.2	26	93.6	84.3	86	138.2	124.5	46	182.8	164.6
7	05.2	04.7	67	49.8	44.8	27	94.4	85.0	87	139.0	125.1	47	183.6	165.3
8	05.9	05.4	68	50.5	45.5	28	95.1	85.6	88	139.7	125.8	48	184.3	165.9
9	06.7	06.0	69	51.3	46.2	29	95.9	86.3	89	140.5	126.5	49	185.0	166.6
10	07.4	06.7	70	52.0	46.8	30	96.6	87.0	90	141.2	127.1	50	185.8	167.3
11	08.2	07.4	71	52.8	47.5	131	97.4	87.7	191	141.9	127.8	251	186.5	168.0
12	08.9	08.0	72	53.5	48.2	32	98.1	88.3	92	142.7	128.5	52	187.3	168.6
13	09.7	08.7	73	54.2	48.8	33	98.8	89.0	93	143.4	129.1	53	188.0	169.3
14	10.4	09.4	74	55.0	49.5	34	99.6	89.7	94	144.2	129.8	54	188.8	170.0
15	11.1	10.0	75	55.7	50.2	35	100.3	90.3	95	144.9	130.5	55	189.5	170.6
16	11.9	10.7	76	56.5	50.9	36	101.1	91.0	96	145.7	131.1	56	190.2	171.3
17	12.6	11.4	77	57.2	51.5	37	101.8	91.7	97	146.4	131.8	57	191.0	172.0
18	13.4	12.0	78	58.0	52.2	38	102.6	92.3	98	147.1	132.5	58	191.7	172.6
19	14.1	12.7	79	58.7	52.9	39	103.3	93.0	99	147.9	133.2	59	192.5	173.3
20	14.9	13.4	80	59.5	53.5	40	104.0	93.7	200	148.6	133.8	60	193.2	174.0
21	15.6	14.1	81	60.2	54.2	141	104.8	94.3	201	149.4	134.5	261	194.0	174.6
22	16.3	14.7	82	60.9	54.9	42	105.5	95.0	02	150.1	135.2	62	194.7	175.3
23	17.1	15.4	83	61.7	55.5	43	106.3	95.7	03	150.9	135.8	63	195.4	176.0
24	17.8	16.1	84	62.4	56.2	44	107.0	96.4	04	151.6	136.5	64	196.2	176.7
25	18.6	16.7	85	63.2	56.9	45	107.8	97.0	05	152.3	137.2	65	196.9	177.3
26	19.3	17.4	86	63.9	57.5	46	108.5	97.7	06	153.1	137.8	66	197.7	178.0
27	20.1	18.1	87	64.7	58.2	47	109.2	98.4	07	153.8	138.5	67	198.4	178.7
28	20.8	18.7	88	65.4	58.9	48	110.0	99.0	08	154.6	139.2	68	199.2	179.3
29	21.6	19.4	89	66.1	59.6	49	110.7	99.7	09	155.3	139.8	69	199.9	180.0
30	22.3	20.1	90	66.9	60.2	50	111.5	100.4	10	156.1	140.5	70	200.6	180.7
31	23.0	20.7	91	67.6	60.9	151	112.2	101.0	211	156.8	141.2	271	201.4	181.3
32	23.8	21.4	92	68.4	61.6	52	113.0	101.7	12	157.5	141.9	72	202.1	182.0
33	24.5	22.1	93	69.1	62.2	53	113.7	102.4	13	158.3	142.5	73	202.9	182.7
34	25.3	22.8	94	69.9	62.9	54	114.4	103.0	14	159.0	143.2	74	203.6	183.3
35	26.0	23.4	95	70.6	63.6	55	115.2	103.7	15	159.8	143.9	75	204.4	184.0
36	26.8	24.1	96	71.3	64.2	56	115.9	104.4	16	160.5	144.5	76	205.1	184.7
37	27.5	24.8	97	72.1	64.9	57	116.7	105.1	17	161.3	145.2	77	205.9	185.3
38	28.2	25.4	98	72.8	65.6	58	117.4	105.7	18	162.0	145.9	78	206.6	186.0
39	29.0	26.1	99	73.6	66.2	59	118.2	106.4	19	162.7	146.5	79	207.3	186.7
40	29.7	26.8	100	74.3	66.9	60	118.9	107.1	20	163.5	147.2	80	208.1	187.4
41	30.5	27.4	101	75.1	67.6	161	119.6	107.7	221	164.2	147.9	281	208.8	188.0
42	31.2	28.1	02	75.8	68.3	62	120.4	108.4	22	165.0	148.5	82	209.6	188.7
43	32.0	28.8	03	76.5	68.9	63	121.1	109.1	23	165.7	149.2	83	210.3	189.4
44	32.7	29.4	04	77.3	69.6	64	121.9	109.7	24	166.5	149.9	84	211.1	190.0
45	33.4	30.1	05	78.0	70.3	65	122.6	110.4	25	167.2	150.6	85	211.8	190.7
46	34.2	30.8	06	78.8	70.9	66	123.4	111.1	26	168.0	151.2	86	212.5	191.4
47	34.9	31.4	07	79.5	71.6	67	124.1	111.7	27	168.7	151.9	87	213.3	192.0
48	35.7	32.1	08	80.3	72.3	68	124.8	112.4	28	169.4	152.6	88	214.0	192.7
49	36.4	32.8	09	81.0	72.9	69	125.6	113.1	29	170.2	153.2	89	214.8	193.4
50	37.2	33.5	10	81.7	73.6	70	126.3	113.8	30	170.9	153.9	90	215.5	194.0
51	37.9	34.1	111	82.5	74.3	171	127.1	114.4	231	171.7	154.6	291	216.3	194.7
52	38.6	34.8	12	83.2	74.9	72	127.8	115.1	32	172.4	155.2	92	217.0	195.4
53	39.4	35.5	13	84.0	75.6	73	128.6	115.8	33	173.2	155.9	93	217.7	196.1
54	40.1	36.1	14	84.7	76.3	74	129.3	116.4	34	173.9	156.6	94	218.5	196.7
55	40.9	36.8	15	85.5	77.0	75	130.1	117.1	35	174.6	157.2	95	219.2	197.4
56	41.6	37.5	16	86.2	77.6	76	130.8	117.8	36	175.4	157.9	96	220.0	198.1
57	42.4	38.1	17	86.9	78.3	77	131.5	118.4	37	176.1	158.6	97	220.7	198.7
58	43.1	38.8	18	87.7	79.0	78	132.3	119.1	38	176.9	159.3	98	221.5	199.4
59	43.8	39.5	19	88.4	79.6	79	133.0	119.8	39	177.6	159.9	99	222.2	200.1
60	44.6	40.1	20	89.2	80.3	80	133.8	120.4	40	178.4	160.6	300	222.9	200.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 48 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 43 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.7	00.7	61	44.6	41.6	121	88.5	82.5	181	132.4	123.4	241	176.3	164.4
2	01.5	01.4	62	45.3	42.3	22	89.2	83.2	82	133.1	124.1	42	177.0	165.0
3	02.2	02.0	63	46.1	43.0	23	90.0	83.9	83	133.8	124.8	43	177.7	165.7
4	02.9	02.7	64	46.8	43.6	24	90.7	84.6	84	134.6	125.5	44	178.5	166.4
5	03.7	03.4	65	47.5	44.3	25	91.4	85.2	85	135.3	126.2	45	179.2	167.1
6	04.4	04.1	66	48.3	45.0	26	92.2	85.9	86	136.0	126.9	46	179.9	167.8
7	05.1	04.8	67	49.0	45.7	27	92.9	86.6	87	136.8	127.5	47	180.6	168.5
8	05.9	05.5	68	49.7	46.4	28	93.6	87.3	88	137.5	128.2	48	181.4	169.1
9	06.6	06.1	69	50.5	47.1	29	94.3	88.0	89	138.2	128.9	49	182.1	169.8
10	07.3	06.8	70	51.2	47.7	30	95.1	88.7	90	139.0	129.6	50	182.8	170.5
11	08.0	07.5	71	51.9	48.4	131	95.8	89.3	191	139.7	130.3	251	183.6	171.2
12	08.8	08.2	72	52.7	49.1	32	96.5	90.0	92	140.4	130.9	52	184.3	171.9
13	09.5	08.9	73	53.4	49.8	33	97.3	90.7	93	141.2	131.6	53	185.0	172.5
14	10.2	09.5	74	54.1	50.5	34	98.0	91.4	94	141.9	132.3	54	185.8	173.2
15	11.0	10.2	75	54.9	51.1	35	98.7	92.1	95	142.6	133.0	55	186.5	173.9
16	11.7	10.9	76	55.6	51.8	36	99.5	92.8	96	143.3	133.7	56	187.2	174.6
17	12.4	11.6	77	56.3	52.5	37	100.2	93.4	97	144.1	134.4	57	188.0	175.3
18	13.2	12.3	78	57.0	53.2	38	100.9	94.1	98	144.8	135.0	58	188.7	176.0
19	13.9	13.0	79	57.8	53.9	39	101.7	94.8	99	145.5	135.7	59	189.4	176.6
20	14.6	13.6	80	58.5	54.6	40	102.4	95.5	200	146.3	136.4	60	190.2	177.3
21	15.4	14.3	81	59.2	55.2	141	103.1	96.2	201	147.0	137.1	261	190.9	178.0
22	16.1	15.0	82	60.0	55.9	42	103.9	96.8	02	147.7	137.8	62	191.6	178.7
23	16.8	15.7	83	60.7	56.6	43	104.6	97.5	03	148.5	138.4	63	192.3	179.4
24	17.6	16.4	84	61.4	57.3	44	105.3	98.2	04	149.2	139.1	64	193.1	180.0
25	18.3	17.0	85	62.2	58.0	45	106.0	98.9	05	149.9	139.8	65	193.8	180.7
26	19.0	17.7	86	62.9	58.7	46	106.8	99.6	06	150.7	140.5	66	194.5	181.4
27	19.7	18.4	87	63.6	59.3	47	107.5	100.3	07	151.4	141.2	67	195.3	182.1
28	20.5	19.1	88	64.4	60.0	48	108.2	100.9	08	152.1	141.9	68	196.0	182.8
29	21.2	19.8	89	65.1	60.7	49	109.0	101.6	09	152.9	142.5	69	196.7	183.5
30	21.9	20.5	90	65.8	61.4	50	109.7	102.3	10	153.6	143.2	70	197.5	184.1
31	22.7	21.1	91	66.6	62.1	151	110.4	103.0	211	154.3	143.9	271	198.2	184.8
32	23.4	21.8	92	67.3	62.7	52	111.2	103.7	12	155.0	144.6	72	198.9	185.5
33	24.1	22.5	93	68.0	63.4	53	111.9	104.3	13	155.8	145.3	73	199.7	186.2
34	24.9	23.2	94	68.7	64.1	54	112.6	105.0	14	156.5	145.9	74	200.4	186.9
35	25.6	23.9	95	69.5	64.8	55	113.4	105.7	15	157.2	146.6	75	201.1	187.5
36	26.3	24.6	96	70.2	65.5	56	114.1	106.4	16	158.0	147.3	76	201.9	188.2
37	27.1	25.2	97	70.9	66.2	57	114.8	107.1	17	158.7	148.0	77	202.6	188.9
38	27.8	25.9	98	71.7	66.8	58	115.6	107.8	18	159.4	148.7	78	203.3	189.6
39	28.5	26.6	99	72.4	67.5	59	116.3	108.4	19	160.2	149.4	79	204.0	190.3
40	29.3	27.3	100	73.1	68.2	60	117.0	109.1	20	160.9	150.0	80	204.8	191.0
41	30.0	28.0	101	73.9	68.9	161	117.7	109.8	221	161.6	150.7	281	205.5	191.6
42	30.7	28.6	02	74.6	69.6	62	118.5	110.5	22	162.4	151.4	82	206.2	192.3
43	31.4	29.3	03	75.3	70.2	63	119.2	111.2	23	163.1	152.1	83	207.0	193.0
44	32.2	30.0	04	76.1	70.9	64	119.9	111.8	24	163.8	152.8	84	207.7	193.7
45	32.9	30.7	05	76.8	71.6	65	120.7	112.5	25	164.6	153.4	85	208.4	194.4
46	33.6	31.4	06	77.5	72.3	66	121.4	113.2	26	165.3	154.1	86	209.2	195.1
47	34.4	32.1	07	78.3	73.0	67	122.1	113.9	27	166.0	154.8	87	209.9	195.7
48	35.1	32.7	08	79.0	73.7	68	122.9	114.6	28	166.7	155.5	88	210.6	196.4
49	35.8	33.4	09	79.7	74.3	69	123.6	115.3	29	167.5	156.2	89	211.4	197.1
50	36.6	34.1	10	80.4	75.0	70	124.3	115.9	30	168.2	156.9	90	212.1	197.8
51	37.3	34.8	111	81.2	75.7	171	125.1	116.6	231	168.9	157.5	291	212.8	198.5
52	38.0	35.5	12	81.9	76.4	72	125.8	117.3	32	169.7	158.2	92	213.6	199.1
53	38.8	36.1	13	82.6	77.1	73	126.5	118.0	33	170.4	158.9	93	214.3	199.8
54	39.5	36.8	14	83.4	77.7	74	127.3	118.7	34	171.1	159.6	94	215.0	200.5
55	40.2	37.5	15	84.1	78.4	75	128.0	119.3	35	171.9	160.3	95	215.7	201.2
56	41.0	38.2	16	84.8	79.1	76	128.7	120.0	36	172.6	161.0	96	216.5	201.9
57	41.7	38.9	17	85.6	79.8	77	129.4	120.7	37	173.3	161.6	97	217.2	202.6
58	42.4	39.6	18	86.3	80.5	78	130.2	121.4	38	174.1	162.3	98	217.9	203.2
59	43.1	40.2	19	87.0	81.2	79	130.9	122.1	39	174.8	163.0	99	218.7	203.9
60	43.9	40.9	20	87.8	81.8	80	131.6	122.8	40	175.5	163.7	300	219.4	204.6
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 47 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 44 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.7	00.7	61	43.9	42.4	121	87.0	84.1	181	130.2	125.7	241	173.4	167.4
2	01.4	01.4	62	44.6	43.1	22	87.8	84.7	82	130.9	126.4	42	174.1	168.1
3	02.2	02.1	63	45.3	43.8	23	88.5	85.4	83	131.6	127.1	43	174.8	168.8
4	02.9	02.8	64	46.0	44.5	24	89.2	86.1	84	132.4	127.8	44	175.5	169.5
5	03.6	03.5	65	46.8	45.2	25	89.9	86.8	85	133.1	128.5	45	176.2	170.2
6	04.3	04.2	66	47.5	45.8	26	90.6	87.5	86	133.8	129.2	46	177.0	170.9
7	05.0	04.9	67	48.2	46.5	27	91.4	88.2	87	134.5	129.9	47	177.7	171.6
8	05.8	05.6	68	48.9	47.2	28	92.1	88.9	88	135.2	130.6	48	178.4	172.3
9	06.5	06.3	69	49.6	47.9	29	92.8	89.6	89	136.0	131.3	49	179.1	173.0
10	07.2	06.9	70	50.4	48.6	30	93.5	90.3	90	136.7	132.0	50	179.8	173.7
11	07.9	07.6	71	51.1	49.3	131	94.2	91.0	191	137.4	132.7	251	180.6	174.4
12	08.6	08.3	72	51.8	50.0	32	95.0	91.7	92	138.1	133.4	52	181.3	175.1
13	09.4	09.0	73	52.5	50.7	33	95.7	92.4	93	138.8	134.1	53	182.0	175.7
14	10.1	09.7	74	53.2	51.4	34	96.4	93.1	94	139.6	134.8	54	182.7	176.4
15	10.8	10.4	75	54.0	52.1	35	97.1	93.8	95	140.3	135.5	55	183.4	177.1
16	11.5	11.1	76	54.7	52.8	36	97.8	94.5	96	141.0	136.2	56	184.2	177.8
17	12.2	11.8	77	55.4	53.5	37	98.5	95.2	97	141.7	136.8	57	184.9	178.5
18	12.9	12.5	78	56.1	54.2	38	99.3	95.9	98	142.4	137.5	58	185.6	179.2
19	13.7	13.2	79	56.8	54.9	39	100.0	96.6	99	143.1	138.2	59	186.3	179.9
20	14.4	13.9	80	57.5	55.6	40	100.7	97.3	200	143.9	138.9	60	187.0	180.6
21	15.1	14.6	81	58.3	56.3	141	101.4	97.9	201	144.6	139.6	261	187.7	181.3
22	15.8	15.3	82	59.0	57.0	42	102.1	98.6	02	145.3	140.3	62	188.5	182.0
23	16.5	16.0	83	59.7	57.7	43	102.9	99.3	03	146.0	141.0	63	189.2	182.7
24	17.3	16.7	84	60.4	58.4	44	103.6	100.0	04	146.7	141.7	64	189.9	183.4
25	18.0	17.4	85	61.1	59.0	45	104.3	100.7	05	147.5	142.4	65	190.6	184.1
26	18.7	18.1	86	61.9	59.7	46	105.0	101.4	06	148.2	143.1	66	191.3	184.8
27	19.4	18.8	87	62.6	60.4	47	105.7	102.1	07	148.9	143.8	67	192.1	185.5
28	20.1	19.5	88	63.3	61.1	48	106.5	102.8	08	149.6	144.5	68	192.8	186.2
29	20.9	20.1	89	64.0	61.8	49	107.2	103.5	09	150.3	145.2	69	193.5	186.9
30	21.6	20.8	90	64.7	62.5	50	107.9	104.2	10	151.1	145.9	70	194.2	187.6
31	22.3	21.5	91	65.5	63.2	151	108.6	104.9	211	151.8	146.6	271	194.9	188.3
32	23.0	22.2	92	66.2	63.9	52	109.3	105.6	12	152.5	147.3	72	195.7	188.9
33	23.7	22.9	93	66.9	64.6	53	110.1	106.3	13	153.2	148.0	73	196.4	189.6
34	24.5	23.6	94	67.6	65.3	54	110.8	107.0	14	153.9	148.7	74	197.1	190.3
35	25.2	24.3	95	68.3	66.0	55	111.5	107.7	15	154.7	149.4	75	197.8	191.0
36	25.9	25.0	96	69.1	66.7	56	112.2	108.4	16	155.4	150.0	76	198.5	191.7
37	26.6	25.7	97	69.8	67.4	57	112.9	109.1	17	156.1	150.7	77	199.3	192.4
38	27.3	26.4	98	70.5	68.1	58	113.7	109.8	18	156.8	151.4	78	200.0	193.1
39	28.1	27.1	99	71.2	68.8	59	114.4	110.5	19	157.5	152.1	79	200.7	193.8
40	28.8	27.8	100	71.9	69.5	60	115.1	111.1	20	158.3	152.8	80	201.4	194.5
41	29.5	28.5	101	72.7	70.2	161	115.8	111.8	221	159.0	153.5	281	202.1	195.2
42	30.2	29.2	02	73.4	70.9	62	116.5	112.5	22	159.7	154.2	82	202.9	195.9
43	30.9	29.9	03	74.1	71.5	63	117.3	113.2	23	160.4	154.9	83	203.6	196.6
44	31.7	30.6	04	74.8	72.2	64	118.0	113.9	24	161.1	155.6	84	204.3	197.3
45	32.4	31.3	05	75.5	72.9	65	118.7	114.6	25	161.9	156.3	85	205.0	198.0
46	33.1	32.0	06	76.3	73.6	66	119.4	115.3	26	162.6	157.0	86	205.7	198.7
47	33.8	32.6	07	77.0	74.3	67	120.1	116.0	27	163.3	157.7	87	206.5	199.4
48	34.5	33.3	08	77.7	75.0	68	120.8	116.7	28	164.0	158.4	88	207.2	200.1
49	35.2	34.0	09	78.4	75.7	69	121.6	117.4	29	164.7	159.1	89	207.9	200.8
50	36.0	34.7	10	79.1	76.4	70	122.3	118.1	30	165.4	159.8	90	208.6	201.5
51	36.7	35.4	111	79.8	77.1	171	123.0	118.8	231	166.2	160.5	291	209.3	202.1
52	37.4	36.1	12	80.6	77.8	72	123.7	119.5	32	166.9	161.2	92	210.0	202.8
53	38.1	36.8	13	81.3	78.5	73	124.4	120.2	33	167.6	161.9	93	210.8	203.5
54	38.8	37.5	14	82.0	79.2	74	125.2	120.9	34	168.3	162.6	94	211.5	204.2
55	39.6	38.2	15	82.7	79.9	75	125.9	121.6	35	169.0	163.2	95	212.2	204.9
56	40.3	38.9	16	83.4	80.6	76	126.6	122.3	36	169.8	163.9	96	212.9	205.6
57	41.0	39.6	17	84.2	81.3	77	127.3	123.0	37	170.5	164.6	97	213.6	206.3
58	41.7	40.3	18	84.9	82.0	78	128.0	123.6	38	171.2	165.3	98	214.4	207.0
59	42.4	41.0	19	85.6	82.7	79	128.8	124.3	39	171.9	166.0	99	215.1	207.7
60	43.2	41.7	20	86.3	83.4	80	129.5	125.0	40	172.6	166.7	300	215.8	208.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 46 Degrees.

Digitized by Google

TABLE II.

Difference of Latitude and Departure for 45 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.7	00.7	61	43.1	43.1	121	85.6	85.6	181	128.0	128.0	241	170.4	170.4
2	01.4	01.4	62	43.8	43.8	22	86.3	86.3	82	128.7	128.7	42	171.1	171.1
3	02.1	02.1	63	44.5	44.5	23	87.0	87.0	83	129.4	129.4	43	171.8	171.8
4	02.8	02.8	64	45.3	45.3	24	87.7	87.7	84	130.1	130.1	44	172.5	172.5
5	03.5	03.5	65	46.0	46.0	25	88.4	88.4	85	130.8	130.8	45	173.2	173.2
6	04.2	04.2	66	46.7	46.7	26	89.1	89.1	86	131.5	131.5	46	173.9	173.9
7	04.9	04.9	67	47.4	47.4	27	89.8	89.8	87	132.2	132.2	47	174.7	174.7
8	05.7	05.7	68	48.1	48.1	28	90.5	90.5	88	132.9	132.9	48	175.4	175.4
9	06.4	06.4	69	48.8	48.8	29	91.2	91.2	89	133.6	133.6	49	176.1	176.1
10	07.1	07.1	70	49.5	49.5	30	91.9	91.9	90	134.4	134.4	50	176.8	176.8
11	07.8	07.8	71	50.2	50.2	131	92.6	92.6	191	135.1	135.1	251	177.5	177.5
12	08.5	08.5	72	50.9	50.9	32	93.3	93.3	92	135.8	135.8	52	178.2	178.2
13	09.2	09.2	73	51.6	51.6	33	94.0	94.0	93	136.5	136.5	53	178.9	178.9
14	09.9	09.9	74	52.3	52.3	34	94.8	94.8	94	137.2	137.2	54	179.6	179.6
15	10.6	10.6	75	53.0	53.0	35	95.5	95.5	95	137.9	137.9	55	180.3	180.3
16	11.3	11.3	76	53.7	53.7	36	96.2	96.2	96	138.6	138.6	56	181.0	181.0
17	12.0	12.0	77	54.4	54.4	37	96.9	96.9	97	139.3	139.3	57	181.7	181.7
18	12.7	12.7	78	55.2	55.2	38	97.6	97.6	98	140.0	140.0	58	182.4	182.4
19	13.4	13.4	79	55.9	55.9	39	98.3	98.3	99	140.7	140.7	59	183.1	183.1
20	14.1	14.1	80	56.6	56.6	40	99.0	99.0	200	141.4	141.4	60	183.8	183.8
21	14.8	14.8	81	57.3	57.3	141	99.7	99.7	201	142.1	142.1	261	184.6	184.6
22	15.6	15.6	82	58.0	58.0	42	100.4	100.4	02	142.8	142.8	62	185.3	185.3
23	16.3	16.3	83	58.7	58.7	43	101.1	101.1	03	143.5	143.5	63	186.0	186.0
24	17.0	17.0	84	59.4	59.4	44	101.8	101.8	04	144.2	144.2	64	186.7	186.7
25	17.7	17.7	85	60.1	60.1	45	102.5	102.5	05	145.0	145.0	65	187.4	187.4
26	18.4	18.4	86	60.8	60.8	46	103.2	103.2	06	145.7	145.7	66	188.1	188.1
27	19.1	19.1	87	61.5	61.5	47	103.9	103.9	07	146.4	146.4	67	188.8	188.8
28	19.8	19.8	88	62.2	62.2	48	104.7	104.7	08	147.1	147.1	68	189.5	189.5
29	20.5	20.5	89	62.9	62.9	49	105.4	105.4	09	147.8	147.8	69	190.2	190.2
30	21.2	21.2	90	63.6	63.6	50	106.1	106.1	10	148.5	148.5	70	190.9	190.9
31	21.9	21.9	91	64.3	64.3	151	106.8	106.8	211	149.2	149.2	271	191.6	191.6
32	22.6	22.6	92	65.1	65.1	52	107.5	107.5	12	149.9	149.9	72	192.3	192.3
33	23.3	23.3	93	65.8	65.8	53	108.2	108.2	13	150.6	150.6	73	193.0	193.0
34	24.0	24.0	94	66.5	66.5	54	108.9	108.9	14	151.3	151.3	74	193.7	193.7
35	24.7	24.7	95	67.2	67.2	55	109.6	109.6	15	152.0	152.0	75	194.5	194.5
36	25.5	25.5	96	67.9	67.9	56	110.3	110.3	16	152.7	152.7	76	195.2	195.2
37	26.2	26.2	97	68.6	68.6	57	111.0	111.0	17	153.4	153.4	77	195.9	195.9
38	26.9	26.9	98	69.3	69.3	58	111.7	111.7	18	154.1	154.1	78	196.6	196.6
39	27.6	27.6	99	70.0	70.0	59	112.4	112.4	19	154.9	154.9	79	197.3	197.3
40	28.3	28.3	100	70.7	70.7	60	113.1	113.1	20	155.6	155.6	80	198.0	198.0
41	29.0	29.0	101	71.4	71.4	161	113.8	113.8	221	156.3	156.3	281	198.7	198.7
42	29.7	29.7	02	72.1	72.1	62	114.6	114.6	22	157.0	157.0	82	199.4	199.4
43	30.4	30.4	03	72.8	72.8	63	115.3	115.3	23	157.7	157.7	83	200.1	200.1
44	31.1	31.1	04	73.5	73.5	64	116.0	116.0	24	158.4	158.4	84	200.8	200.8
45	31.8	31.8	05	74.2	74.2	65	116.7	116.7	25	159.1	159.1	85	201 5	201.5
46	32.5	32.5	06	75.0	75.0	66	117.4	117.4	26	159.8	159.8	86	202.2	202.2
47	33.2	33.2	07	75.7	75.7	67	118.1	118.1	27	160.5	160.5	87	202.9	202.9
48	33.9	33.9	08	76.4	76.4	68	118.8	118.8	28	161.2	161.2	88	203.6	203.6
49	34.6	34.6	09	77.1	77.1	69	119.5	119.5	29	161.9	161.9	89	204.4	204.4
50	35.4	35.4	10	77.8	77.8	70	120.2	120.2	30	162.6	162.6	90	205.1	205.1
51	36.1	36.1	111	78.5	78.5	171	120.9	120.9	231	163.3	163.3	291	205.8	205.8
52	36.8	36.8	12	79.2	79.2	72	121.6	121.6	32	164.0	164.0	92	206.5	206 5
53	37.5	37.5	13	79.9	79.9	73	122.3	122.3	33	164.8	164.8	93	207.2	207 2
54	38.2	38.2	14	80.6	80.6	74	123.0	123.0	34	165.5	165.5	94	207.9	207.9
55	38.9	38.9	15	81.3	81.3	75	123.7	123.7	35	166.2	166.2	95	208.6	208.6
56	39.6	39.6	16	82.0	82.0	76	124.5	124.5	36	166.9	166.9	96	209.3	209.3
57	40.3	40.3	17	82.7	82.7	77	125.2	125.2	37	167.6	167.6	97	210.0	210.0
58	41.0	41.0	18	83.4	83.4	78	125.9	125.9	38	168.3	168.3	98	210.7	210.7
59	41.7	41.7	19	84.1	84.1	79	126.6	126.6	39	169.0	169.0	99	211.4	211.4
60	42.4	42.4	20	84.9	84.9	80	127.3	127.3	40	169.7	169.7	300	212.1	212.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

TABLE III.

Meridional Parts.

M.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	M.
0	0	60	120	180	240	300	361	421	482	542	603	664	725	787	0
1	1	61	121	181	241	301	362	422	483	543	604	665	726	788	1
2	2	62	122	182	242	302	363	423	484	544	605	666	727	789	2
3	3	63	123	183	243	303	364	424	485	545	606	667	728	790	3
4	4	64	124	184	244	304	365	425	486	546	607	668	729	791	4
5	5	65	125	185	245	305	366	426	487	547	608	669	730	792	5
6	6	66	126	186	246	306	367	427	488	548	609	670	731	793	6
7	7	67	127	187	247	307	368	428	489	549	610	671	732	794	7
8	8	68	128	188	248	308	369	429	490	550	611	672	734	795	8
9	9	69	129	189	249	309	370	430	491	551	612	673	735	796	9
10	10	70	130	190	250	310	371	431	492	552	613	674	736	797	10
11	11	71	131	191	251	311	372	432	493	553	614	675	737	798	11
12	12	72	132	192	252	312	373	433	494	554	615	676	738	799	12
13	13	73	133	193	253	313	374	434	495	555	616	677	739	800	13
14	14	74	134	194	254	314	375	435	496	556	617	678	740	801	14
15	15	75	135	195	255	315	376	436	497	557	618	679	741	802	15
16	16	76	136	196	256	316	377	437	498	558	619	680	742	803	16
17	17	77	137	197	257	317	378	438	499	559	620	681	743	804	17
18	18	78	138	198	258	318	379	439	500	560	621	682	744	805	18
19	19	79	139	199	259	319	380	440	501	561	622	683	745	806	19
20	20	80	140	200	260	320	381	441	502	562	623	684	746	807	20
21	21	81	141	201	261	321	382	442	503	564	624	685	747	808	21
22	22	82	142	202	262	322	383	443	504	565	625	687	748	809	22
23	23	83	143	203	263	323	384	444	505	566	626	688	749	810	23
24	24	84	144	204	264	324	385	445	506	567	627	689	750	811	24
25	25	85	145	205	265	325	386	446	507	568	628	690	751	812	25
26	26	86	146	206	266	326	387	447	508	569	629	691	752	813	26
27	27	87	147	207	267	327	388	448	509	570	631	692	753	815	27
28	28	88	148	208	268	328	389	449	510	571	632	693	754	816	28
29	29	89	149	209	269	330	390	450	511	572	633	694	755	817	29
30	30	90	150	210	270	331	391	451	512	573	634	695	756	818	30
31	31	91	151	211	271	332	392	452	513	574	635	696	757	819	31
32	32	92	152	212	272	333	393	453	514	575	636	697	758	820	32
33	33	93	153	213	273	334	394	454	515	576	637	698	759	821	33
34	34	94	154	214	274	335	395	455	516	577	638	699	760	822	34
35	35	95	155	215	275	336	396	456	517	578	639	700	761	823	35
36	36	96	156	216	276	337	397	457	518	579	640	701	762	824	36
37	37	97	157	217	277	338	398	458	519	580	641	702	763	825	37
38	38	98	158	218	278	339	399	459	520	581	642	703	764	826	38
39	39	99	159	219	279	340	400	460	521	582	643	704	765	827	39
40	40	100	160	220	280	341	401	461	522	583	644	705	766	828	40
41	41	101	161	221	281	342	402	462	523	584	645	706	767	829	41
42	42	102	162	222	282	343	403	463	524	585	646	707	768	830	42
43	43	103	163	223	283	344	404	464	525	586	647	708	769	831	43
44	44	104	164	224	284	345	405	465	526	587	648	709	770	832	44
45	45	105	165	225	285	346	406	466	527	588	649	710	771	833	45
46	46	106	166	226	286	347	407	467	528	589	650	711	772	834	46
47	47	107	167	227	287	348	408	468	529	590	651	712	773	835	47
48	48	108	168	228	288	349	409	469	530	591	652	713	774	836	48
49	49	109	169	229	289	350	410	470	531	592	653	714	775	837	49
50	50	110	170	230	290	351	411	471	532	593	654	715	777	838	50
51	51	111	171	231	291	352	412	472	533	594	655	716	778	839	51
52	52	112	172	232	292	353	413	473	534	595	656	717	779	840	52
53	53	113	173	233	293	354	414	474	535	596	657	718	780	841	53
54	54	114	174	234	294	355	415	476	536	597	658	719	781	842	54
55	55	115	175	235	295	356	416	477	537	598	659	720	782	843	55
56	56	116	176	236	296	357	417	478	538	599	660	721	783	844	56
57	57	117	177	237	297	358	418	479	539	600	661	722	784	845	57
58	58	118	178	238	298	359	419	480	540	601	662	723	785	846	58
59	59	119	179	239	299	360	420	481	541	602	663	724	786	847	59
M.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	M.

Digitized by Google

TABLE III.

Meridional Parts.

M.	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	M.
0	848	910	973	1035	1098	1161	1225	1289	1354	1419	1484	1550	1616	1684	0
1	850	911	974	36	99	63	26	90	55	20	85	51	18	85	1
2	851	913	975	37	1100	64	27	91	56	21	86	52	19	86	2
3	852	914	976	38	01	65	28	92	57	22	87	53	20	87	3
4	853	915	977	39	02	66	29	93	58	23	88	54	21	88	4
5	854	916	978	1041	1103	1167	1230	1295	1359	1424	1490	1556	1622	1689	5
6	855	917	979	42	05	68	32	96	60	25	91	57	23	90	6
7	856	918	980	43	06	69	33	97	61	26	92	58	24	91	7
8	857	919	981	44	07	70	34	98	62	27	93	59	25	93	8
9	858	920	982	45	08	71	35	99	63	28	94	60	26	94	9
10	859	921	983	1046	1109	1172	1236	1300	1364	1430	1495	1561	1628	1695	10
11	860	922	984	47	10	73	37	01	66	31	96	62	29	96	11
12	861	923	985	48	11	74	38	02	67	32	97	63	30	97	12
13	862	924	986	49	12	75	39	03	68	33	98	64	31	98	13
14	863	925	987	50	13	76	40	04	69	34	99	65	32	99	14
15	864	926	988	1051	1114	1177	1241	1305	1370	1435	1500	1567	1633	1700	15
16	865	927	989	52	15	78	42	06	71	36	02	68	34	01	16
17	866	928	990	53	16	79	43	07	72	37	03	69	35	03	17
18	867	929	991	54	17	81	44	08	73	38	04	70	37	04	18
19	868	930	993	55	18	82	45	10	74	39	05	71	38	05	19
20	869	931	994	1056	1119	1183	1246	1311	1375	1440	1506	1572	1639	1706	20
21	870	932	995	57	20	84	48	12	76	41	07	73	40	07	21
22	871	933	996	58	21	85	49	13	77	43	08	74	41	08	22
23	872	934	997	59	22	86	50	14	79	44	09	75	42	09	23
24	873	935	998	60	23	87	51	15	80	45	10	77	43	11	24
25	874	936	999	1061	1125	1188	1252	1316	1381	1446	1511	1578	1644	1712	25
26	875	937	1000	63	26	89	53	17	82	47	13	79	45	13	26
27	876	938	01	64	27	90	54	18	83	48	14	80	47	14	27
28	877	939	02	65	28	91	55	19	84	49	15	81	48	15	28
29	878	941	03	66	29	92	56	20	85	50	16	82	49	16	29
30	879	942	1004	1067	1130	1193	1257	1321	1386	1451	1517	1583	1650	1717	30
31	880	943	05	68	31	94	58	22	87	52	18	84	51	18	31
32	882	944	06	69	32	95	59	24	88	53	19	85	52	20	32
33	883	945	07	70	33	96	60	25	89	55	20	86	53	21	33
34	884	946	08	71	34	98	61	26	90	56	21	88	54	22	34
35	885	947	1009	1072	1135	1199	1262	1327	1392	1457	1522	1589	1656	1723	35
36	886	948	10	73	36	1200	64	28	93	58	24	90	57	24	36
37	887	949	11	74	37	01	65	29	94	59	25	91	58	25	37
38	888	950	12	75	38	02	66	30	95	60	26	92	59	26	38
39	889	951	13	76	39	03	67	31	96	61	27	93	60	27	39
40	890	952	1014	1077	1140	1204	1268	1332	1397	1462	1528	1594	1661	1729	40
41	891	953	15	78	41	05	69	33	98	63	29	95	62	30	41
42	892	954	16	79	42	06	70	34	99	64	30	96	63	31	42
43	893	955	18	80	44	07	71	35	1400	65	31	98	64	32	43
44	894	956	19	81	45	08	72	36	01	67	32	99	66	33	44
45	895	957	1020	1082	1146	1209	1273	1338	1402	1468	1533	1600	1667	1734	45
46	896	958	21	84	47	10	74	39	03	69	35	01	68	35	46
47	897	959	22	85	48	11	75	40	05	70	36	02	69	36	47
48	898	960	23	86	49	12	76	41	06	71	37	03	70	38	48
49	899	961	24	87	50	13	77	42	07	72	38	04	71	39	49
50	900	962	1025	1088	1151	1215	1278	1343	1408	1473	1539	1605	1672	1740	50
51	901	963	26	89	52	16	80	44	09	74	40	06	73	41	51
52	902	964	27	90	53	17	81	45	10	75	41	08	75	42	52
53	903	965	28	91	54	18	82	46	11	76	42	09	76	43	53
54	904	966	29	92	55	19	83	47	12	77	43	10	77	44	54
55	905	968	1030	1093	1156	1220	1284	1348	1413	1479	1544	1611	1678	1746	55
56	906	969	31	94	57	21	85	49	14	80	46	12	79	47	56
57	907	970	32	95	58	22	86	50	15	81	47	13	80	48	57
58	908	971	33	96	59	23	87	52	16	82	48	14	81	49	58
59	909	972	34	97	60	24	88	53	18	83	49	15	82	50	59
M.	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	M

Digitized by Google

TABLE III

Meridional Parts.

M.	28°	29°	30°	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°	41°	M.
0	1751	1819	1888	1958	2028	2100	2171	2244	2318	2393	2468	2545	2623	2702	0
1	52	21	90	59	30	01	73	46	19	94	70	46	24	03	1
2	53	22	91	60	31	02	74	47	20	95	71	48	25	04	2
3	55	23	92	62	32	03	75	48	22	96	72	49	27	06	3
4	56	24	93	63	33	04	76	49	23	98	73	50	28	07	4
5	1757	1825	1894	1964	2034	2105	2178	2250	2324	2399	2475	2551	2629	2708	5
6	58	26	95	65	35	07	79	52	25	2400	76	53	31	10	6
7	59	27	96	66	37	08	80	53	27	01	77	54	32	11	7
8	60	29	98	67	38	09	81	54	28	03	78	55	33	12	8
9	61	30	99	69	39	10	82	55	29	04	80	57	34	14	9
10	1762	1831	1900	1970	2040	2111	2184	2257	2330	2405	2481	2558	2636	2715	10
11	64	32	01	71	41	13	85	58	32	06	82	59	37	16	11
12	65	33	02	72	43	14	86	59	33	08	84	60	38	18	12
13	66	34	03	73	44	15	87	60	34	09	85	62	40	19	13
14	67	35	05	74	45	16	88	61	35	10	86	63	41	20	14
15	1768	1837	1906	1976	2046	2117	2190	2263	2337	2411	2487	2564	2642	2722	15
16	69	38	07	77	47	19	91	64	38	13	89	66	44	23	16
17	70	39	08	78	48	20	92	65	39	14	90	67	45	24	17
18	72	40	09	79	50	21	93	66	40	15	91	68	46	26	18
19	73	41	10	80	51	22	94	68	42	16	92	69	48	27	19
20	1774	1842	1912	1981	2052	2123	2196	2269	2343	2418	2494	2571	2649	2728	20
21	75	43	13	83	53	25	97	70	44	19	95	72	50	29	21
22	76	45	14	84	54	26	98	71	45	20	96	73	51	31	22
23	77	46	15	85	56	27	99	72	46	22	98	75	53	32	23
24	78	47	16	86	57	28	2200	74	48	23	99	76	54	33	24
25	1780	1848	1917	1987	2058	2129	2202	2275	2349	2424	2500	2577	2655	2735	25
26	81	49	18	88	59	31	03	76	50	25	01	78	57	36	26
27	82	50	20	90	60	32	04	77	51	27	03	80	58	37	27
28	83	52	21	91	61	33	05	79	53	28	04	81	59	39	28
29	84	53	22	92	63	34	07	80	54	29	05	82	61	40	29
30	1785	1854	1923	1993	2064	2135	2208	2281	2355	2430	2506	2584	2662	2742	30
31	86	55	24	94	65	37	09	82	56	32	08	85	63	43	31
32	87	56	25	95	66	38	10	83	58	33	09	86	65	44	32
33	89	57	27	97	67	39	11	85	59	34	10	88	66	46	33
34	90	58	28	98	69	40	13	86	60	35	12	89	67	47	34
35	1791	1860	1929	1999	2070	2141	2214	2287	2361	2437	2513	2590	2669	2748	35
36	92	61	30	2000	71	43	15	88	63	38	14	91	70	50	36
37	93	62	31	01	72	44	16	90	64	39	15	93	71	51	37
38	94	63	32	02	73	45	17	91	65	40	17	94	73	52	38
39	95	64	34	04	75	46	19	92	66	42	18	95	74	54	39
40	1797	1865	1935	2005	2076	2147	2220	2293	2368	2443	2519	2597	2675	2755	40
41	98	66	36	06	77	49	21	95	69	44	21	98	76	56	41
42	99	68	37	07	78	50	22	96	70	45	22	99	78	58	42
43	1800	69	38	08	79	51	24	97	71	47	23	2601	79	59	43
44	01	70	39	10	80	52	25	98	73	48	24	02	80	60	44
45	1802	1871	1941	2011	2082	2153	2226	2299	2374	2449	2526	2603	2682	2762	45
46	03	72	42	12	83	55	27	2301	75	51	27	04	83	63	46
47	05	73	43	13	84	56	28	02	76	52	28	06	84	64	47
48	06	75	44	14	85	57	30	03	78	53	30	07	86	66	48
49	07	76	45	15	86	58	31	04	79	54	31	08	87	67	49
50	1808	1877	1946	2017	2088	2159	2232	2306	2380	2456	2532	2610	2688	2768	50
51	09	78	48	18	89	61	33	07	81	57	33	11	90	70	51
52	10	79	49	19	90	62	35	08	83	58	35	12	91	71	52
53	11	80	50	20	91	63	36	09	84	59	36	14	92	72	53
54	13	81	51	21	92	64	37	11	85	61	37	15	94	74	54
55	1814	1883	1952	2022	2094	2165	2238	2312	2386	2462	2538	2616	2695	2775	55
56	15	84	53	24	95	67	39	13	88	63	40	17	96	76	56
57	16	85	55	25	96	68	41	14	89	64	41	19	98	78	57
58	17	86	56	26	97	69	42	16	90	66	42	20	99	79	58
59	18	87	57	27	98	70	43	17	91	67	44	21	2700	80	59
M.	28°	29°	30°	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°	41°	M.

Digitized by Google

TABLE III.

Meridional Parts.

M.	42°	43°	44°	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	M.
0	2782	2863	2946	3030	3116	3203	3292	3382	3474	3569	3665	3764	3865	3968	0
1	83	64	47	31	17	04	93	84	76	70	67	65	66	70	1
2	84	66	49	33	18	06	95	85	78	72	68	67	68	71	2
3	86	67	50	34	20	07	96	87	79	74	70	69	70	73	3
4	87	69	51	36	21	09	98	88	81	75	72	70	71	75	4
5	2788	2870	2953	3037	3123	3210	3299	3390	3482	3577	3673	3772	3873	3977	5
6	90	71	54	38	24	12	3301	91	84	78	75	74	75	78	6
7	91	73	56	40	26	13	02	93	85	80	77	75	77	80	7
8	92	74	57	41	27	14	03	94	87	82	78	77	78	82	8
9	94	75	58	43	29	16	05	96	88	83	80	79	80	84	9
10	2795	2877	2960	3044	3130	3217	3306	3397	3490	3585	3681	3780	3882	3985	10
11	97	78	61	46	31	19	08	99	92	86	83	82	83	87	11
12	98	80	63	47	33	20	09	3400	93	88	85	84	85	89	12
13	99	81	64	48	34	22	11	02	95	90	86	85	87	91	13
14	2801	82	65	50	36	23	12	03	96	91	88	87	89	92	14
15	2802	2884	2967	3051	3137	3225	3314	3405	3498	3593	3690	3789	3890	3994	15
16	03	85	68	53	39	26	16	07	99	94	91	90	92	96	16
17	05	86	70	54	40	28	17	08	3501	96	93	92	94	98	17
18	06	88	71	55	42	29	19	10	03	98	95	94	95	99	18
19	07	89	72	57	43	31	20	11	04	99	96	95	97	4001	19
20	2809	2891	2974	3058	3144	3232	3322	3413	3506	3601	3698	3797	3899	4003	20
21	10	92	75	60	46	34	23	14	07	02	99	99	3901	05	21
22	11	93	76	61	47	35	25	16	09	04	3701	3800	02	06	22
23	13	95	78	63	49	37	26	17	10	06	03	02	04	08	23
24	14	96	79	64	50	38	28	19	12	07	04	04	06	10	24
25	2815	2897	2981	3065	3152	3240	3329	3420	3514	3609	3706	3806	3907	4012	25
26	17	99	82	67	53	41	31	22	15	10	08	07	09	14	26
27	18	2900	83	68	55	42	32	23	17	12	09	09	11	15	27
28	20	02	85	70	56	44	34	25	18	14	11	11	13	17	28
29	21	03	86	71	57	45	35	27	20	15	13	12	14	19	29
30	2822	2904	2988	3073	3159	3247	3337	3428	3521	3617	3714	3814	3916	4021	30
31	24	06	89	74	60	48	38	30	23	18	16	16	18	22	31
32	25	07	91	75	62	50	40	31	25	20	17	17	19	24	32
33	26	08	92	77	63	51	41	33	26	22	19	19	21	26	33
34	28	10	93	78	65	53	43	34	28	23	21	21	23	28	34
35	2829	2911	2995	3080	3166	3254	3344	3436	3529	3625	3722	3822	3925	4029	35
36	30	13	96	81	68	56	46	37	31	26	24	24	26	31	36
37	32	14	98	83	69	57	47	39	32	28	26	26	28	33	37
38	33	15	99	84	71	59	49	40	34	30	27	27	30	35	38
39	34	17	3000	85	72	60	50	42	36	31	29	29	32	37	39
40	2836	2918	3002	3087	3173	3262	3352	3443	3537	3633	3731	3831	3933	4038	40
41	37	19	03	88	75	63	53	45	39	34	32	32	35	40	41
42	39	21	05	90	76	65	55	47	40	36	34	34	37	42	42
43	40	22	06	91	78	66	56	48	42	38	36	36	38	44	43
44	41	24	07	93	79	68	58	50	43	39	37	38	40	45	44
45	2843	2925	3009	3094	3181	3269	3359	3451	3545	3641	3739	3839	3942	4047	45
46	44	26	10	95	82	71	61	53	47	43	41	41	44	49	46
47	45	28	12	97	84	72	62	54	48	44	42	43	45	51	47
48	47	29	13	98	85	74	64	56	50	46	44	44	47	52	48
49	48	31	14	3100	87	75	65	57	51	47	46	46	49	54	49
50	2849	2932	3016	3101	3188	3277	3367	3459	3553	3649	3747	3848	3951	4056	50
51	51	33	17	03	90	78	68	60	55	51	49	49	52	58	51
52	52	35	19	04	91	80	70	62	56	52	50	51	54	60	52
53	54	36	20	05	92	81	71	64	58	54	52	53	56	61	53
54	55	37	21	07	94	83	73	65	59	55	54	54	58	63	54
55	2856	2939	3023	3108	3195	3284	3374	3467	3561	3657	3755	3856	3959	4065	55
56	58	40	24	10	97	86	76	68	62	59	57	58	61	67	56
57	59	42	26	11	98	87	78	70	64	60	59	60	63	69	57
58	60	43	27	13	3200	89	79	71	66	62	60	61	64	70	58
59	62	44	29	14	01	90	81	73	67	64	62	63	66	72	59
M.	42°	43°	44°	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	M.

Digitized by Google

TABLE III.

Meridional Parts.

M.	56°	57°	58°	59°	60°	61°	62°	63°	64°	65°	66°	67°	68°	69°	M.
0	4074	4183	4294	4409	4527	4649	4775	4905	5039	5179	5324	5474	5631	5795	0
1	76	84	96	11	29	51	77	07	42	81	26	77	33	97	1
2	77	86	98	13	31	53	79	09	44	84	28	79	36	5800	2
3	79	88	4300	15	33	55	81	12	46	86	31	82	39	03	3
4	81	90	02	17	35	57	84	14	49	88	33	84	42	06	4
5	4083	4192	4304	4419	4537	4660	4786	4916	5051	5191	5336	5487	5644	5809	5
6	85	94	06	21	39	62	88	18	53	93	38	89	47	11	6
7	86	95	08	23	41	64	90	20	55	95	41	92	50	14	7
8	88	97	09	25	43	66	92	23	58	98	43	95	52	17	8
9	90	99	11	27	45	68	94	25	60	5200	46	97	55	20	9
10	4092	4201	4313	4429	4547	4670	4796	4927	5062	5203	5348	5500	5658	5823	10
11	94	03	15	31	49	72	98	29	65	05	51	02	60	25	11
12	95	05	17	33	51	74	4801	31	67	07	53	05	63	28	12
13	97	07	19	34	53	76	03	34	69	10	56	07	66	31	13
14	99	08	21	36	55	78	05	36	71	12	58	10	68	34	14
15	4101	4210	4323	4438	4557	4680	4807	4938	5074	5214	5361	5513	5671	5837	15
16	03	12	25	40	59	82	09	40	76	17	63	15	74	39	16
17	04	14	27	42	62	84	11	43	78	19	66	18	76	42	17
18	06	16	28	44	64	87	14	45	81	22	68	20	79	45	18
19	08	18	30	46	66	89	16	47	83	24	71	23	82	48	19
20	4110	4220	4332	4448	4568	4691	4818	4949	5085	5226	5373	5526	5685	5851	20
21	12	21	34	50	70	93	20	51	88	29	76	28	87	54	21
22	13	23	36	52	72	95	22	54	90	31	78	31	90	56	22
23	15	25	38	54	74	97	24	56	92	34	80	33	93	59	23
24	17	27	40	56	76	99	26	58	95	36	83	36	95	62	24
25	4119	4229	4342	4458	4578	4701	4829	4960	5097	5238	5385	5539	5698	5865	25
26	21	31	44	60	80	03	31	63	99	41	88	41	5701	68	26
27	22	32	46	62	82	05	33	65	5102	43	90	44	04	71	27
28	24	34	47	64	84	07	35	57	04	46	93	46	06	74	28
29	26	36	49	66	86	10	37	9	06	48	95	49	09	76	29
30	4128	4238	4351	4468	4588	4712	4839	4972	5108	5250	5398	5552	5712	5879	30
31	30	40	53	70	90	14	42	74	11	53	5401	54	15	82	31
32	32	42	55	72	92	16	44	76	13	55	03	57	17	85	32
33	33	44	57	74	94	18	46	78	15	58	06	59	20	88	33
34	35	46	59	76	96	20	48	81	18	60	08	62	23	91	34
35	4137	4247	4361	4478	4598	4722	4850	4983	5120	5263	5411	5565	5725	5894	35
36	39	49	63	80	4600	24	52	85	22	65	13	67	28	96	36
37	41	51	65	82	02	26	55	87	25	67	16	70	31	99	37
38	42	53	67	84	04	28	57	90	27	70	18	73	34	5902	38
39	44	55	69	86	06	31	59	92	29	72	21	75	36	05	39
40	4146	4257	4370	4488	4608	4733	4861	4994	5132	5275	5423	5578	5739	5908	40
41	48	59	72	90	10	35	63	96	34	77	26	80	42	11	41
42	50	60	74	92	12	37	65	99	36	80	28	83	45	14	42
43	52	62	76	94	14	39	68	5001	39	82	31	86	47	17	43
44	53	64	78	95	16	41	70	03	41	84	33	88	50	19	44
46	4155	4266	4380	4497	4618	4743	4872	5005	5143	5287	5436	5591	5753	5922	45
46	57	68	82	99	20	45	74	08	46	89	38	94	56	25	46
47	59	70	84	4501	23	47	76	10	48	92	41	96	58	28	47
48	61	72	86	03	25	50	79	12	51	94	43	99	61	31	48
49	62	74	88	05	27	52	81	14	53	97	46	5602	64	34	49
50	4164	4275	4390	4507	4629	4754	4883	5017	5155	5299	5448	5604	5767	5937	50
51	66	77	92	09	31	56	85	19	58	5301	51	07	70	40	51
52	68	79	94	11	33	58	87	21	60	04	54	10	72	43	52
53	70	81	96	13	35	60	90	23	62	06	56	12	75	46	53
54	72	83	98	15	37	62	92	26	65	09	59	15	78	48	54
55	4173	4285	4399	4517	4639	4764	4894	5028	5167	5311	5461	5617	5781	5951	55
56	75	87	4401	19	41	66	96	30	69	14	64	20	83	54	56
57	77	89	03	21	43	69	98	33	72	16	66	23	86	57	57
58	79	91	05	23	45	71	4901	35	74	19	69	25	89	60	58
59	81	92	07	25	47	73	03	37	76	21	71	28	92	63	59
M.	56°	57°	58°	59°	60°	61°	62°	63°	64°	65°	66°	67°	68°	69°	M.

Digitized by Google

TABLE III.

Meridional Parts.

M.	70°	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°	81°	82°	83°	M.
0	5966	6146	6335	6534	6746	6970	7210	7467	7745	8046	8375	8739	9145	9606	0
1	69	49	38	38	49	74	14	72	49	51	81	45	53	14	1
2	72	52	41	41	53	78	18	76	54	56	87	52	60	22	2
3	75	55	45	45	57	82	22	81	59	61	93	58	67	31	3
4	78	58	48	48	60	86	27	85	64	67	98	65	74	39	4
5	5981	6161	6351	6552	6764	6990	7231	7490	7769	8072	8404	8771	9182	9647	5
6	84	64	54	55	68	94	35	94	74	77	10	78	89	55	6
7	86	67	58	58	71	97	39	98	78	83	16	84	96	64	7
8	89	70	61	62	75	7001	43	7503	83	88	22	91	9203	72	8
9	92	73	64	65	79	05	47	07	88	93	27	97	11	80	9
10	5995	6177	6367	6569	6782	7009	7252	7512	7793	8099	8433	8804	9218	9689	10
11	98	80	71	72	86	13	56	16	98	8104	39	10	25	97	11
12	6001	83	74	76	90	17	60	21	7803	09	45	17	33	9706	12
13	04	86	77	79	93	21	64	25	08	15	51	23	40	14	13
14	07	89	80	83	97	25	68	30	13	20	57	30	48	23	14
15	6010	6192	6384	6586	6801	7029	7273	7535	7817	8125	8463	8836	9255	9731	15
16	13	95	87	90	04	33	77	39	22	31	69	43	62	40	16
17	16	98	90	93	08	37	81	44	27	36	74	49	70	48	17
18	19	6201	94	97	12	41	85	48	32	41	80	56	77	57	18
19	22	05	97	6600	15	45	89	53	37	47	86	63	85	65	19
20	6025	6208	6400	6603	6819	7048	7294	7557	7842	8152	8492	8869	9292	9774	20
21	28	11	03	07	23	52	98	62	47	58	98	76	9300	83	21
22	31	14	07	10	26	56	7302	66	52	63	8504	83	07	91	22
23	34	17	10	14	30	60	06	71	57	68	10	89	15	9800	23
24	37	20	13	17	34	64	11	76	62	74	16	96	22	09	24
25	6040	6223	6417	6621	6838	7068	7315	7580	7867	8179	8522	8903	9330	9817	25
26	43	26	20	24	41	72	19	85	72	85	28	09	37	26	26
27	46	30	23	28	45	76	23	89	77	90	34	16	45	35	27
28	49	33	27	31	49	80	28	94	82	96	40	23	53	44	28
29	52	36	30	35	53	84	32	99	87	8201	46	30	60	52	29
30	6055	6239	6433	6639	6856	7088	7336	7603	7892	8207	8552	8936	9368	9861	30
31	58	42	37	42	60	92	41	08	97	12	58	43	76	70	31
32	61	45	40	46	64	96	45	12	7902	18	65	50	83	79	32
33	64	49	43	49	68	7100	49	17	07	23	71	57	91	88	33
34	67	52	47	53	71	04	53	22	12	29	77	63	99	97	34
35	6070	6255	6450	6656	6875	7108	7358	7626	7917	8234	8583	8970	9407	9906	35
36	73	58	53	60	79	12	62	31	22	40	89	77	14	15	36
37	76	61	57	63	83	16	66	36	27	45	95	84	22	24	37
38	79	64	60	67	86	20	71	40	32	51	8601	91	30	33	38
39	82	68	63	70	90	24	75	45	37	56	07	98	38	42	39
40	6085	6271	6467	6674	6894	7128	7379	7650	7942	8262	8614	9005	9445	9951	40
41	88	74	70	77	98	32	84	54	48	67	20	12	53	60	41
42	91	77	73	81	6901	36	88	59	53	73	26	18	61	69	42
43	94	80	77	85	05	40	92	64	58	79	32	25	69	78	43
44	97	83	80	88	09	45	97	68	63	84	38	32	77	87	44
45	6100	6287	6483	6692	6913	7149	7401	7673	7968	8290	8644	9039	9485	9996	45
46	03	90	87	95	17	53	06	78	73	95	51	46	93	10005	46
47	06	93	90	99	20	57	10	83	78	8301	57	53	9501	10015	47
48	09	96	94	6702	24	61	14	87	83	07	63	60	09	10024	48
49	12	99	97	06	28	65	19	92	89	12	69	67	17	10033	49
50	6115	6303	6500	6710	6932	7169	7423	7697	7994	8318	8676	9074	9525	10043	50
51	18	06	04	13	36	73	27	7702	99	24	82	81	33	10052	51
52	21	09	07	17	40	77	32	06	8004	29	88	88	41	10061	52
53	24	12	11	20	43	81	36	11	09	35	95	96	49	10071	53
54	27	15	14	24	47	85	41	16	14	41	8701	9103	57	10080	54
55	6130	6319	6517	6728	6951	7189	7445	7721	8020	8347	8707	9110	9565	10089	55
56	33	22	21	31	55	94	49	25	25	52	14	17	73	10099	56
57	36	25	24	35	59	98	54	30	30	58	20	24	81	10108	57
58	40	28	28	38	63	7202	58	35	35	64	26	31	89	10118	58
59	43	32	31	42	66	06	63	40	40	69	33	38	98	10127	59
M.	70°	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°	81°	82°	83°	M.

Digitized by Google

TABLE IV.

The Sun's Declination for Apparent Noon at Greenwich, for the year 1864, which will answer nearly for the years 1868, 1872, 1876.

Days.	JAN.	FEB.	MAR.	APRIL.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	Days.
	South.	*South.*	*South.*	*North.*	*North.*	*North.*	*North.*	*North.*	*North.*	*South.*	*South.*	*South.*	
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
1	23. 3	17.13	7.22	4.45	15.14	22. 8	23. 5	17.55	8. 6	3.23	14.37	21.54	1
2	22.58	16.56	6.59	5. 8	15.32	22.16	23. 1	17.39	7.45	3.47	14.56	22. 3	2
3	22.52	16.38	6.36	5.31	15.50	22.23	22.56	17.23	7.22	4.10	15.15	22.12	3
4	22.46	16.21	6.13	5.54	16. 7	22.30	22.51	17. 7	7. 0	4.33	15.33	22.20	4
5	22.40	16. 3	5.50	6.17	16.24	22.37	22.45	16.51	6.38	4.56	15.51	22.27	5
6	22.33	15.45	5.26	6.40	16.41	22.43	22.39	16.35	6.16	5.19	16. 9	22.34	6
7	22.26	15.26	5. 3	7. 2	16.58	22.49	22.33	16.18	5.53	5.42	16.27	22.41	7
8	22.18	15. 7	4.40	7.25	17.14	22.54	22.26	16. 1	5.31	6. 5	16.45	22.47	8
9	22.10	14.48	4.16	7.47	17.30	22.59	22.19	15.44	5. 8	6.28	17. 2	22.53	9
10	22. 2	14.29	3.53	8. 9	17.46	23. 4	22.11	15.26	4.45	6.51	17.19	22.59	10
11	21.53	14. 9	3.29	8.31	18. 1	23. 8	22. 3	15. 8	4.22	7.13	17.35	23. 4	11
12	21.43	13.50	3. 6	8.53	18.16	23.12	21.55	14.50	3.59	7.36	17.51	23. 8	12
13	21.33	13.30	2.42	9 15	18.31	23.15	21.46	14.32	3.36	7.58	18. 7	23.12	13
14	21.23	13. 9	2.18	9.36	18.45	23.18	21.37	14.13	3.13	8.21	18.23	23.16	14
15	21.12	12.49	1.55	9.58	19. 0	23.21	21.28	13.55	2.50	8.43	18.38	23.19	15
16	21. 1	12.28	1.31	10.19	19.13	23.23	21.18	13.36	2.27	9. 5	18.53	23.21	16
17	20.50	12. 8	1. 7	10.40	19.27	23.24	21. 8	13.17	2. 4	9.27	19. 8	23.23	17
18	20.38	11.46	0.43	11. 1	19.40	23.26	20.57	12.57	1.41	9.49	19.22	23.25	18
19	20.25	11.25	*S.*0.20	11.22	19.53	23.27	20.46	12.38	1.17	10.11	19.36	23.26	19
20	20.13	11. 4	*N.*0 4	11.42	20. 6	23.27	20.35	12.18	0.54	10.32	19.50	23.27	20
21	20. 0	10.42	0.28	12. 3	20.18	23.27	20.24	11.58	0.31	10.54	20. 3	23.27	21
22	19.46	10.21	0.51	12.23	20.30	23.27	20.12	11.38	*N.*0. 7	11.15	20.16	23.27	22
23	19.33	9.59	1.15	12.43	20.41	23.26	19.59	11.17	*S.*0.16	11.36	20.28	23.26	23
24	19.18	9.37	1.38	13. 2	20.52	23.25	19.47	10.57	0.40	11.57	20.41	23.25	24
25	19. 4	9.15	2. 2	13.22	21. 3	23.23	19.34	10.36	1. 3	12.17	20.52	23.24	25
26	18.49	8.52	2.26	13.41	21.13	23.22	19.21	10.15	1.26	12.38	21. 4	23.21	26
27	18.34	8.30	2.49	14. 0	21.23	23.19	19. 7	9.54	1.50	12.58	21.15	23.19	27
28	18.18	8. 7	3.12	14.19	21.33	23.16	18.53	9.33	2.13	13.18	21.25	23.16	28
29	18. 3	7.45	3.36	14.38	21.42	23.13	18.39	9.11	2.37	13.38	21.35	23.12	29
30	17.46		3.59	14.56	21.51	23. 9	18.24	8.50	3. 0	13.58	21.45	23. 8	30
31	17.30		4.22		22. 0		18.10	8.28		14.18		23. 4	31

TABLE IV. A.—The Equation of Time for Apparent Noon at Greenwich, for 1864, or nearly for 1868, 1872, 1876. To be applied to the App. Time.

Days.	JAN.	FEB.	MAR.	APRIL.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	Days.
	Add to App. Time.	*Add to App. Time.*	*Add to App. Time.*	*Add to App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	*Add to App. Time.*	*Add to App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	
	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	
1	3.38	13.49	12.29	3.49	3. 5	2.25	3.34	6. 1	0.17	10.29	16.18	10.35	1
2	4. 6	13.57	12.16	3.31	3.12	2.16	3.45	5.57	0.36	10.48	16.19	10.12	2
3	4.34	14. 4	12. 4	3.13	3.18	2. 6	3.57	5.52	0.55	11. 6	16.18	9.48	3
4	5. 2	14.11	11.50	2.55	3.24	1.56	4. 7	5.47	1.14	11.24	16.17	9.23	4
5	5.29	14.16	11.37	2.38	3.30	1.46	4.18	5.41	1.34	11.42	16.15	8.58	5
6	5.56	14.21	11.22	2.21	3 34	1.35	4.28	5.35	1 54	11.59	16.12	8.32	6
7	6.23	14.24	11. 8	2. 4	3.38	1.24	4.38	5.28	2.14	12.16	16. 9	8. 6	7
8	6.49	14.28	10.53	1.47	3.42	1.12	4 47	5.20	2.35	12 33	16. 4	7.40	8
9	7.14	14.30	10.38	1.30	3.45	1. 1	4.56	5.12	2.55	12.49	15.59	7.13	9
10	7.39	14.31	10.22	1.14	3.48	0.49	5. 5	5. 3	3.16	13. 5	15.53	6.46	10
11	8. 3	14.32	10. 6	0.57	3.49	0.37	5.13	4.54	3.37	13.20	15.46	6.18	11
12	8.27	14.32	9.50	0.42	3.51	0.25	5.21	4.44	3.58	13.35	15.38	5.50	12
13	8.50	14.31	9.33	0.26	3.52	0.12	5.28	4.33	4.19	13.49	15.30	5.21	13
14	9.13	14.29	9.16	0.11	3.52	0. 0	5.34	4.22	4.40	14. 3	15.20	4.53	14
15	9.34	14.27	8.59	*S.*0. 4	3.52	*A.*0 13	5.40	4.11	5. 1	14.16	15.10	4.24	15
16	9.55	14.23	8.42	0.19	3.51	0.26	5.46	3.58	5.22	14.28	14.59	3.54	16
17	10.16	14.20	8.24	0.33	3.49	0.38	5.51	3.46	5.44	14.40	14.47	3.25	17
18	10.35	14.15	8. 6	0.47	3.47	0.51	5.56	3.32	6. 5	14.52	14.34	2.55	18
19	10.54	14. 9	7.48	1. 0	3.45	1. 4	6. 0	3.19	6.26	15. 3	14.20	2.25	19
20	11.13	14. 3	7.30	1.13	3.42	1.17	6. 3	3. 5	6.47	15.13	14. 6	1.56	20
21	11.30	13.57	7.12	1.26	3.38	1.30	6. 6	2.50	7. 8	15.22	13.51	1.26	21
22	11.47	13.49	6.53	1.38	3.34	1.43	6. 9	2.35	7.29	15.31	13.34	0.56	22
23	12. 2	13.41	6.35	1.50	3.30	1.56	6.10	2.19	7.50	15.39	13.18	0.25	23
24	12.17	13.33	6.17	2. 1	3.24	2. 8	6.12	2. 4	8.10	15.46	13. 0	*A.*0 5	24
25	12.32	13.23	5.58	2.12	3.19	2.21	6.12	1.47	8.31	15.53	12.41	0.35	25
26	12.45	13.14	5.39	2.22	3.13	2.34	6.12	1.31	8.51	15.59	12.22	1. 4	26
27	12.58	13. 3	5.21	2.31	3. 6	2.46	6.12	1.14	9.11	16. 4	12. 2	1.34	27
28	13.10	12.52	5. 2	2.41	2.59	2.58	6.11	0.56	9.31	16. 8	11.41	2. 4	28
29	13.21	12.41	4.44	2.49	2.51	3.10	6. 9	0.38	9.51	16.12	11.20	2.33	29
30	13.31		4.26	2.57	2.43	3.22	6. 7	0.20	10.10	16.15	10.58	3. 2	30
31	13.41		4. 7		2.34		6. 4	0. 2		16.17		3.31	31

Digitized by Google

TABLE IV.

The Sun's Declination for Apparent Noon at Greenwich, for the year 1865, which will answer nearly for the years 1869, 1873, 1877.

Days.	JAN.	FEB.	MAR.	APRIL.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	Days.
	South.	*South.*	*South.*	*North.*	*North.*	*North.*	*North.*	*North.*	*North.*	*South.*	*South.*	*South.*	
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
1	22.59	17. 0	7.27	4.40	15.10	22. 6	23. 6	17.58	8.12	3.18	14.32	21.52	1
2	22.54	16.43	7. 4	5. 3	15.28	22.14	23. 2	17.43	7.50	3.41	14.51	22. 1	2
3	22.48	16.25	6.41	5.26	15.46	22.21	22.57	17.27	7.28	4. 4	15.10	22.10	3
4	22.42	16. 7	6.18	5.49	16. 3	22.28	22.52	17.11	7. 6	4.27	15.29	22.18	4
5	22.35	15.49	5.55	6.11	16.20	22.35	22.47	16.55	6.43	4.51	15.47	22.25	5
6	22.28	15.31	5.32	6.34	16.37	22.41	22.41	16.39	6.21	5.14	16. 5	22.33	6
7	22.20	15.12	5. 9	6.57	16.54	22.47	22.35	16.22	5.59	5.37	16.23	22.40	7
8	22.12	14.53	4.45	7.19	17.10	22.53	22.28	16. 5	5.36	6. 0	16.40	22.46	8
9	22. 4	14.34	4.22	7.41	17.26	22.58	22.21	15.48	5.13	6.22	16.58	22.52	9
10	21.55	14.14	3.58	8. 4	17.42	23. 3	22.13	15.30	4.51	6.45	17.14	22.57	10
11	21.45	13.54	3.35	8.26	17.57	23. 7	22. 5	15.13	4.28	7. 8	17.31	23. 2	11
12	21.36	13.35	3.11	8.48	18.12	23.11	21.57	14.55	4. 5	7.30	17.47	23. 7	12
13	21.25	13.14	2.48	9 9	18.27	23.14	21.49	14.36	3.42	7.53	18. 3	23.11	13
14	21.15	12.54	2.24	9.31	18.42	23.17	21.40	14.18	3.19	8.15	18.19	23.15	14
15	21. 4	12.33	2. 0	9.52	18.56	23.20	21.30	13.59	2.56	8.38	18.35	23.18	15
16	20.52	12.13	1.37	10.14	19.10	23.22	21.20	13.40	2.33	9. 0	18.50	23.21	16
17	20.41	11.52	1.13	10.35	19.24	23.24	21.10	13.21	2. 9	9.22	19. 4	23.23	17
18	20.29	11.31	0.49	10.56	19.37	23.25	21. 0	13. 2	1.46	9.44	19.19	23.25	18
19	20.16	11. 9	0.26	11.17	19.50	23.26	20.49	12.42	1.23	10. 5	19.33	23.26	19
20	20. 3	10.48	*S.*0. 2	11.37	20. 2	23.27	20.38	12.23	1. 0	10.27	19.47	23.27	20
21	19.50	10.26	*N.*0 22	11.58	20.15	23.27	20.26	12. 3	0.36	10.48	20. 0	23.27	21
22	19.36	10. 4	0.45	12.18	20.27	23.27	20.15	11.42	*N.*0 13	11.10	20.13	23.27	22
23	19.22	9.42	1. 9	12.38	20.38	23.26	20. 2	11.22	*S.*0.11	11.31	20.25	23.27	23
24	19. 7	9.20	1.33	12.58	20.49	23.25	19.50	11. 2	0.34	11.52	20.38	23.25	24
25	18.53	8.58	1.56	13.17	21. 0	23.24	19.37	10.41	0.57	12.13	20.49	23.24	25
26	18.38	8.35	2.20	13.37	21.11	23.22	19.24	10.20	1.21	12.33	21. 1	23.22	26
27	18.22	8.13	2.43	13.56	21.21	23.20	19.10	9.59	1.44	12.53	21.12	23.20	27
28	18. 6	7.50	3. 7	14.15	21.31	23.17	18.57	9.38	2. 8	13.14	21.23	23.17	28
29	17.50		3.30	14.33	21.40	23.14	18.42	9.17	2.31	13.34	21.33	23.13	29
30	17.34		3.53	14.52	21.49	23.10	18.28	8.55	2.54	13.53	21.43	23. 9	30
31	17.17		4.17		21.58		18.13	8.33		14.13		23. 5	31

TABLE IV. A.—The Equation of Time for Apparent Noon at Greenwich, for 1865, or nearly for 18 9, 1873, 1877. To be applied to the App. Time.

Days.	JAN.	FEB.	MAR.	APRIL.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	Days.
	Add to App. Time.	*Add to App. Time.*	*Add to App. Time.*	*Add to App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	*Add to App. Time.*	*Add to App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	
	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	
1	4. 0	13.56	12.32	3.54	3. 3	2.28	3.31	6. 2	0.11	10.24	16.17	10.40	1
2	4.28	14. 3	12.20	3.36	3.10	2.18	3.43	5.58	0.30	10.42	16.18	10.17	2
3	4.56	14.10	12. 7	3.18	3.17	2. 9	3.54	5.54	0.50	11. 1	16.18	9.54	3
4	5.23	14.15	11.54	3. 0	3.23	1.59	4. 5	5.49	1. 9	11.19	16.17	9.29	4
5	5.50	14.20	11.40	2.42	3.28	1.49	4.15	5.42	1.29	11.37	16.16	9. 5	5
6	6.16	14.24	11.26	2.25	3.33	1.38	4.25	5.36	1 49	11.55	16.13	8.39	6
7	6.42	14.27	11.12	2. 8	3.38	1.27	4.35	5.29	2. 9	12.12	16.10	8.13	7
8	7. 8	14.29	10.57	1.51	3.42	1.16	4 44	5.22	2.30	12 29	16. 6	7.47	8
9	7.33	14.31	10.41	1.34	3.45	1. 5	4.53	5.14	2.50	12.45	16. 1	7.20	9
10	7.57	14.31	10.26	1.17	3.48	0.53	5. 2	5. 5	3.11	13. 1	15.55	6.53	10
11	8.21	14.31	10.10	1. 1	3.50	0.41	5.10	4.56	3.32	13.16	15.48	6.25	11
12	8.44	14.30	9.53	0.45	3.52	0.29	5.18	4.46	3.53	13.31	15.41	5.57	12
13	9. 6	14.29	9.37	0.29	3.53	0.17	5.25	4.35	4.14	13.45	15.32	5.29	13
14	9.28	14.26	9.20	0.14	3.53	0. 4	5.32	4.24	4.35	13.59	15.23	5. 0	14
15	9.49	14.23	9. 2	*S.*0. 2	3.53	*A.*0. 8	5.38	4.13	4.56	14.12	15.12	4 31	15
16	10.10	14.20	8.45	0.16	3.52	0.21	5.44	4. 1	5.17	14.25	15. 1	4. 1	16
17	10.30	14.15	8.27	0.31	3.51	0.34	5.49	3.49	5.38	14.37	14.49	3.32	17
18	10.49	14.10	8.10	0.44	3.49	0.47	5.54	3.36	5.59	14.48	14.37	3. 2	18
19	11. 7	14. 4	7.52	0.58	3.47	1. 0	5.58	3.22	6.20	14.59	14.23	2.32	19
20	11.25	13.58	7.34	1.11	3.44	1.13	6. 2	3. 8	6.41	15. 9	14. 9	2. 2	20
21	11.42	13.51	7.16	1.23	3.40	1.26	6. 5	2.54	7. 2	15.19	13.53	1.32	21
22	11.58	13.43	6.57	1.36	3.36	1.39	6. 8	2.39	7.23	15.28	13.37	1. 2	22
23	12.13	13.35	6.39	1.47	3.31	1.52	6.10	2.24	7.44	15.36	13.21	0.32	23
24	12.28	13.26	6.21	1.58	3.26	2. 5	6.12	2. 8	8. 4	15.43	13. 3	0. 2	24
25	12.42	13.16	6. 2	2. 9	3.20	2.18	6.13	1.52	8.25	15.50	12.45	*A.*0.28	25
26	12.55	13. 6	5.44	2.19	3.14	2.31	6.13	1.36	8.45	15.56	12.26	0.58	26
27	13. 7	12.55	5.26	2.29	3. 8	2.43	6.13	1.19	9. 5	16. 2	12. 6	1.28	27
28	13.19	12.44	5. 7	2.38	3. 0	2.56	6.12	1. 2	9.25	16. 6	11.46	1.57	28
29	13.29		4.49	2.47	2.53	3. 8	6.10	0.44	9.45	16.10	11.25	2.26	29
30	13.39		4.30	2.55	2.45	3.20	6. 8	0.26	10. 4	16.13	11. 3	2.55	30
31	13.48		4.12		2.36		6. 6	0. 7		16.16		3.24	31

Digitized by Google

TABLE IV.

The Sun's Declination for Apparent Noon at Greenwich, for the year 1866, which will answer nearly for the years 1870, 1874, 1878.

Days.	JAN.	FEB.	MAR.	APRIL.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	Days.
	South.	South.	South.	North.	North.	North.	North.	North.	North.	South.	South.	South.	
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
1	23. 0	17. 4	7.33	4.34	15. 5	22. 4	23. 7	18. 2	8.17	3.12	14.27	21.50	1
2	22.55	16.47	7.10	4.57	15.23	22.12	23. 3	17.47	7.55	3.35	14.47	21.59	2
3	22.49	16.29	6.47	5.20	15.41	22.19	22.59	17.31	7.33	3.58	15. 5	22. 8	3
4	22.43	16.12	6.24	5.43	15.59	22.27	22.54	17.15	7.11	4.22	15.24	22.16	4
5	22.37	15.53	6. 1	6. 6	16.16	22.33	22.48	16.59	6.49	4.45	15.42	22.24	5
6	22.30	15.35	5.38	6.29	16.33	22.10	22.42	16.43	6.27	5. 8	16. 1	22.31	6
7	22.22	15.16	5.14	6.51	16.50	22.46	22.36	16.26	6. 4	5.31	16.18	22.38	7
8	22.14	14.58	4.51	7.14	17. 6	22.51	22.29	16. 9	5.42	5.54	16.36	22.44	8
9	22. 6	14.38	4.28	7.36	17.22	22.57	22.22	15.52	5.19	6.17	16.53	22.50	9
10	21.57	14.19	4. 4	7.58	17.38	23. 1	22.15	15.35	4.56	6.40	17.10	22.56	10
11	21.48	13.59	3.41	8.20	17.54	23. 6	22. 7	15.17	4.33	7. 2	17.27	23. 1	11
12	21.38	13.39	3.17	8.42	18. 9	23.10	21.59	14.59	4.10	7.25	17.43	23. 6	12
13	21.28	13.19	2.54	9 4	18.24	23.13	21.51	14.41	3.48	7.48	18. 0	23.10	13
14	21.17	12.59	2.30	9.26	18.38	23.17	21.42	14.22	3.24	8.10	18.15	23.14	14
15	21. 7	12.38	2. 6	9.47	18.53	23.19	21.32	14. 4	3. 1	8.32	18.31	23.17	15
16	20.55	12.18	1.43	10. 9	19. 7	23.22	21.23	13.45	2.38	8.54	18.46	23.20	16
17	20.44	11.57	1.19	10.30	19.20	23.24	21.13	13.26	2.15	9.16	19. 1	23.22	17
18	20.31	11.36	0.55	10.51	19.34	23.25	21. 2	13. 6	1.52	9.38	19.15	23.24	18
19	20.19	11 14	0.31	11.12	19.47	23.26	20.52	12.47	1.29	10. 0	19.29	23.26	19
20	20. 6	10.53	S.0. 8	11.32	19.59	23.27	20.41	12.27	1. 5	10.22	19.43	23.27	20
21	19.53	10.31	N.0 16	11.53	20.12	23.27	20.29	12. 7	0.42	10.43	19.57	23.27	21
22	19.39	10. 9	0.40	12.13	20.24	23.27	20.17	11.47	N.0 18	11. 5	20.10	23.27	22
23	19.25	9.47	1. 3	12.33	20.35	23.27	20. 5	11.27	S.0. 5	11.26	20.22	23.27	23
24	19.11	9.25	1.27	12.53	20.47	23.26	19.53	11. 7	0.28	11.47	20.35	23.26	24
25	18.56	9. 3	1.51	13.12	20.58	23.24	19.40	10.46	0.52	12. 7	20.47	23.24	25
26	18.41	8.41	2.14	13.32	21. 8	23.22	19.27	10.25	1.15	12.28	20.58	23.23	26
27	18.26	8.18	2.38	13.51	21.18	23.20	19.14	10. 4	1.39	12.48	21. 9	23.20	27
28	18.10	7.56	3. 1	14.10	21.28	23.18	19. 0	9.43	2. 2	13. 9	21.20	23.17	28
29	17.54		3.24	14.29	21.38	23.15	18.46	9.22	2.25	13.29	21.30	23.14	29
30	17.38		3.48	14.47	21.47	23.11	18.32	9. 0	2.49	13.48	21.40	23.10	30
31	17.21		4.11		21.56		18.17	8.39		14. 8		23. 6	31

Table IV. A.—The Equation of Time for Apparent Noon at Greenwich, for 1866, or nearly for 1870, 1874, 1878. To be applied to the App. Time.

Days.	JAN.	FEB.	MAR.	APRIL.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	Days.
	Add to App. Time.	*Add to App. Time.*	*Add to App. Time.*	*Add to App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	*Add to App. Time.*	*Add to App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	
	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	
1	3.52	13.53	12.35	3.58	3. 2	2.31	3.28	6. 2	0. 7	10.20	16.18	10.47	1
2	4.20	14. 1	12.22	3.39	3. 9	2.22	3.39	5.59	0.26	10.38	16.19	10.24	2
3	4.48	14. 7	12.10	3.21	3.16	2.12	3.50	5.54	0.45	10.57	16.19	10. 1	3
4	5.16	14.13	11.56	3. 3	3.22	2. 2	4. 1	5.49	1. 5	11.15	16.18	9.37	4
5	5.43	14.18	11.43	2.46	3.28	1.52	4.12	5.44	1.24	11.33	16.17	9.12	5
6	6. 9	14.22	11.29	2.28	3.33	1.42	4.22	5.38	1.44	11.51	16.14	8.46	6
7	6.35	14.25	11.14	2.11	3.38	1.31	4.32	5.31	2. 4	12. 8	16.11	8.20	7
8	7. 1	14.28	10.59	1.54	3.42	1.19	4.42	5.24	2.25	12.25	16. 7	7.54	8
9	7.26	14.29	10.44	1.37	3.45	1. 8	4.51	5.16	2.45	12.41	16. 2	7.27	9
10	7.50	14.30	10.29	1.20	3.48	0.56	5. 0	5. 7	3. 6	12.57	15.56	7. 0	10
11	8.14	14.31	10.13	1. 4	3.50	0.44	5. 8	4.58	3.26	13.12	15.50	6.32	11
12	8.38	14.30	9.56	0.48	3.52	0.32	5.16	4.49	3.47	13.27	15.42	6. 4	12
13	9. 0	14.29	9.40	0.32	3.53	0.19	5.24	4.39	4. 8	13.41	15.34	5.36	13
14	9.23	14.27	9.23	0.17	3.53	0. 7	5.31	4.28	4.29	13.55	15.25	5. 7	14
15	9.44	14.24	9. 6	0. 2	3.53	A.0. 6	5.37	4.17	4.50	14. 9	15.15	4.38	15
16	10. 5	14.21	8.49	S.0.13	3.52	0.19	5.43	4. 5	5.11	14.21	15. 4	4. 9	16
17	10.25	14.17	8.32	0.27	3.51	0.32	5.49	3.53	5.32	14.34	14.52	3.40	17
18	10.44	14.12	8.14	0.41	3.49	0.45	5.54	3.40	5.53	14.45	14.40	3.10	18
19	11. 3	14. 6	7.56	0.54	3.47	0.58	5.58	3.26	6.15	14.56	14.27	2.40	19
20	11.21	14. 0	7.38	1. 7	3.44	1.11	6. 2	3.13	6.36	15. 7	14.13	2.11	20
21	11.38	13.53	7.20	1.20	3.41	1.24	6. 5	2.58	6.57	15.17	13.58	1.41	21
22	11.55	13.45	7. 2	1.32	3.37	1.36	6. 8	2.43	7.18	15.26	13.42	1.11	22
23	12.10	13.37	6.44	1.44	3.32	1.49	6.10	2.28	7.39	15.34	13.26	0.41	23
24	12.25	13.28	6.25	1.56	3.27	2. 2	6.12	2.12	7.59	15.42	13. 9	0.11	24
25	12.39	13.18	6. 7	2. 7	3.22	2.15	6.13	1.56	8.20	15.49	12.51	A.0.19	25
26	12.52	13. 8	5.48	2.17	3.16	2.27	6.13	1.40	8.41	15.56	12.32	0.48	26
27	13. 4	12.58	5.30	2.27	3. 9	2.40	6.13	1.23	9. 1	16. 1	12.13	1.18	27
28	13.16	12.46	5.11	2.37	3. 3	2.52	6.12	1. 5	9.21	16. 6	11.52	1.48	28
29	13.26		4.53	2.46	2.55	3. 4	6.10	0.48	9.41	16.11	11.31	2.17	29
30	13.36		4.34	2.54	2.48	3.16	6. 8	0.30	10. 0	16.14	11.10	2.46	30
31	13.45		4.16		2.39		6. 6	0.11		16.16		3.15	31

Digitized by Google

TABLE IV.

The Sun's Declination for Apparent Noon at Greenwich, for the year 1867, which will answer nearly for the years 1871, 1875, 1879.

Days.	JAN.	FEB.	MAR.	APRIL.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	Days.
	South.	*South.*	*South.*	*North.*	*North.*	*North.*	*North.*	*North.*	*North.*	*South.*	*South.*	*South.*	
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
1	23. 1	17. 8	7.39	4.28	15. 1	22. 2	23. 8	18. 5	8.22	3. 6	14.23	21.47	1
2	22.56	16.51	7.16	4.52	15.19	22.10	23. 4	17.50	8. 0	3.30	14.42	21.57	2
3	22.51	16.34	6.53	5.15	15.37	22.18	23. 0	17.35	7.38	3.53	15. 1	22. 5	3
4	22.45	16.16	6.30	5.38	15.55	22.25	22.55	17.19	7.16	4.16	15.20	22.14	4
5	22.38	15.58	6. 7	6. 0	16.12	22.32	22.49	17. 3	6.54	4.39	15.38	22.22	5
6	22.31	15.40	5.43	6.23	16.29	22.38	22.44	16.47	6.32	5. 2	15.56	22.29	6
7	22.24	15.21	5.20	6.46	16.46	22.44	22.38	16.30	6.10	5.25	16.14	22.36	7
8	22.16	15. 2	4.57	7. 8	17. 2	22.50	22.31	16.13	5.47	5.48	16.32	22.43	8
9	22. 8	14.43	4.33	7.31	17.18	22.55	22.24	15.56	5.24	6.11	16.49	22.49	9
10	21.59	14.24	4.10	7.53	17.34	23. 0	22.17	15.39	5. 2	6.34	17. 6	22.55	10
11	21.50	14. 4	3.46	8.15	17.50	23. 5	22. 9	15.21	4.39	6.57	17.23	23. 0	11
12	21.40	13.44	3.23	8.37	18. 5	23. 9	22. 1	15. 3	4.16	7.20	17.39	23. 5	12
13	21.30	13.24	2.59	8 59	18.20	23.13	21.53	14.45	3.53	7.42	17.56	23. 9	13
14	21.20	13. 4	2.36	9.21	18.35	23.16	21.44	14.27	3.30	8. 4	18.12	23.13	14
15	21. 9	12.44	2.12	9.42	18.49	23.19	21.35	14. 8	3. 7	8.27	18.27	23.16	15
16	20.58	12.23	1.48	10. 3	19. 3	23.21	21.25	13.49	2.44	8.49	18.42	23.19	16
17	20.47	12. 2	1.25	10.25	19.17	23.23	21.15	13.30	2.21	9.11	18.57	23.22	17
18	20.35	11.41	1. 1	10.46	19.31	23.25	21. 5	13.11	1.57	9.33	19.12	23.24	18
19	20.22	11 20	0.37	11. 7	19.44	23.26	20.54	12.52	1.34	9.55	19.26	23.25	19
20	20. 9	10.58	*S.*0.13	11.27	19.56	23.27	20.43	12.32	1.11	10.16	19.40	23.26	20
21	19.56	10.37	*N.*0.10	11.48	20. 9	23.27	20.32	12.12	0.48	10.38	19.53	23.27	21
22	19.43	10.15	0.34	12. 8	20.21	23.27	20.20	11.52	0.24	10.59	20. 6	23.27	22
23	19.29	9.53	0.58	12.28	20.33	23.27	20. 8	11.32	*N.*0. 1	11.20	20.19	23.27	23
24	19.15	9.31	1.21	12.48	20.44	23.26	19.56	11.12	*S.*0.23	11.42	20.32	23.26	24
25	19. 0	9. 9	1.45	13. 8	20.55	23.25	19.43	10.51	0.46	12. 2	20.44	23.25	25
26	18.45	8.46	2 8	13.27	21. 6	23.23	19.30	10.30	1. 9	12.23	20.55	23.23	26
27	18.30	8.24	2.32	13.46	21.16	23.21	19.17	10. 9	1.33	12.43	21. 7	23.21	27
28	18.14	8. 1	2.55	14. 5	21.26	23.18	19. 3	9.48	1.56	13. 4	21.17	23.18	28
29	17.58		3.19	14.24	21.35	23.15	18.49	9.27	2.20	13.24	21.28	23.15	29
30	17.42		3.42	14.43	21.45	23.12	18.35	9. 6	2.43	13.44	21.38	23.11	30
31	17.25		4. 5		21.54		18.20	8.44		14. 3		23. 7	31

TABLE IV. A.—The Equation of Time for Apparent Noon at Greenwich, for 1867, or nearly for 1871, 1875, 1879. To be applied to the App. Time.

Days.	JAN.	FEB.	MAR.	APRIL.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	Days.
	Add to App. Time.	*Add to App. Time.*	*Add to App. Time.*	*Add to App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	*Add to App. Time.*	*Add to App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	*Sub. fr. App. Time.*	
	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	
1	3.44	13.50	12.37	4. 2	2.59	2.31	3.27	6. 5	0. 2	10.14	16.17	10.53	1
2	4.12	13.58	12.25	3.44	3. 6	2.22	3.38	6. 1	0.20	10.33	16.18	10.30	2
3	4.40	14. 5	12.12	3.26	3.13	2.12	3.50	5.57	0.39	10.52	16.19	10. 7	3
4	5. 8	14.11	11.59	3. 9	3.19	2. 2	4. 1	5.52	0.59	11.10	16.18	9.43	4
5	5.35	14.16	11.46	2.51	3.25	1.52	4.12	5.47	1.18	11.28	16.17	9.18	5
6	6. 2	14.21	11.32	2.34	3.30	1.42	4.22	5.41	1 38	11.46	16.15	8.53	6
7	6.28	14.24	11.18	2.16	3.35	1.31	4.32	5.34	1.58	12. 8	16.12	8.27	7
8	6.54	14.27	11. 3	1.59	3.39	1.20	4.42	5.27	2.19	12 20	16. 8	8. 1	8
9	7.19	14.29	10.48	1.42	3.42	1. 8	4.51	5.19	2.39	12.37	16. 4	7.35	9
10	7.44	14.30	10.33	1.26	3.45	0.57	5. 0	5.11	3. 0	12.53	15.58	7. 8	10
11	8. 8	14.31	10.17	1. 9	3.47	0.45	5. 8	5. 2	3.21	13. 8	15.52	6.40	11
12	8.31	14.30	10. 1	0.53	3.49	0.33	5.16	4.52	3.42	13.24	15.45	6.12	12
13	8.54	14.29	9.45	0.38	3.51	0.20	5.23	4.42	4. 3	13.38	15.37	5.44	13
14	9.17	14.27	9.28	0.22	3.51	0. 8	5.30	4.31	4.24	13.52	15.28	5.16	14
15	9.38	14.25	9.11	0. 7	3.51	*A* 0 4	5.37	4.20	4.45	14. 6	15.19	4 47	15
16	9.59	14.21	8.54	*S.*0. 8	3.51	0.17	5.43	4. 8	5. 6	14.19	15. 8	4.18	16
17	10.19	14.17	8.36	0.23	3.50	0.30	5.48	3.56	5.27	14.32	14.57	3.49	17
18	10.39	14.12	8.19	0.37	3.48	0.43	5.53	3.43	5.49	14.43	14.45	3.19	18
19	10.57	14. 6	8. 1	0.50	3.46	0.55	5.58	3.30	6.10	14.55	14.31	2.19	19
20	11.15	14. 0	7.43	1. 4	3.44	1. 8	6. 2	3.16	6.31	15. 5	14.18	2.19	20
21	11.32	13.53	7.25	1.17	3.41	1.21	6. 5	3. 2	6.52	15.15	14. 3	1.50	21
22	11.49	13.46	7. 6	1.29	3.37	1.34	6. 8	2.47	7.13	15.24	13.47	1.19	22
23	12. 4	13.38	6.48	1.41	3.32	1.47	6.10	2.32	7.34	15.33	13.31	0.49	23
24	12.19	13.29	6.29	1.53	3.28	2. 0	6.12	2.16	7.54	15.41	13.14	0.19	24
25	12.33	13.20	6.11	2. 4	3.22	2.13	6.13	2. 0	8.15	15.48	12.56	*A* 0 11	25
26	12.47	13.10	5.53	2.14	3.16	2.25	6.14	1.44	8.35	15.54	12.37	0.41	26
27	12.59	12.59	5.34	2.24	3.10	2.38	6.14	1.27	8.56	16. 0	12.18	1.11	27
28	13.11	12.48	5.16	2.34	3. 3	2.50	6.13	1.10	9.16	16. 5	11.57	1.40	28
29	13.22		4.57	2.43	2.56	3. 3	6.12	0.53	9.35	16. 9	11.37	2.10	29
30	13.32		4.39	2.51	2.48	3.15	6.10	0.35	9.55	16.13	11.15	2.39	30
31	13.42		4.21		2.40		6. 8	0.17		16.15		3. 8	31

Digitized by Google

TABLE V.

For reducing the Sun's Declination, as given in the Nautical Almanac for Noon at Greenwich, to any other Time under any other Meridian.

Add aft. N. Sub. bef. N.	Sub. aft. N. Add bef. N.	H.M 0. 20	H.M 0. 40	H.M 1. 0	H.M 1. 20	H.M 1. 40	H.M 2. 0	H.M 2. 20	H.M 2. 40	Sub. aft. N. Add bef. N.	Add aft. N. Sub. bef. N.
Add in W. Sub. in E.	Sub. in W. Add in E.	5 Deg.	10 Deg.	15 Deg.	20 Deg.	25 Deg.	30 Deg.	35 Deg.	40 Deg.	Sub. in W. Add in E.	Add in W. Sub. in E.
Days.	Days.	M.S.	M.S.	M.S.	M.S.	M.S.	M.S.	M.S.	M.S.	Days.	Days.
Decemb. 21	Decemb. 21	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	21 June	21 June
20	22	0. 0	0. 1	0. 1	0. 1	0. 2	0. 2	0. 2	0. 3	22	20
19	23	0. 0	0. 1	0. 2	0. 2	0. 3	0. 4	0. 5	0. 6	23	19
18	24	0. 1	0. 2	0. 3	0. 4	0. 6	0. 7	0. 8	0. 9	24	18
17	25	0. 1	0. 3	0. 4	0. 6	0. 7	0. 9	0.11	0.12	25	17
16	26	0. 2	0. 4	0. 5	0. 7	0. 9	0.11	0.13	0.15	26	16
15	27	0. 2	0. 5	0. 6	0. 8	0.11	0.13	0.15	0.18	27	15
14	28	0. 3	0. 6	0. 7	0.10	0.12	0.15	0.18	0.21	28	14
13	29	0. 3	0. 7	0. 9	0.12	0.15	0.18	0.21	0.24	29	13
12	30	0. 3	0. 7	0.10	0.13	0.17	0.20	0.23	0.27	30 June	12
11	Decemb. 31	0. 4	0. 8	0.11	0.15	0.19	0.22	0.26	0.30	1 July	11
10	January 1	0. 4	0. 8	0.12	0.16	0.20	0.24	0.28	0.32	2	10
9	2	0. 4	0. 8	0.13	0.17	0.21	0.26	0.30	0.35	3	9
8	3	0. 5	0. 9	0.14	0.19	0.24	0.29	0.33	0.38	4	8
7	4	0. 5	0.10	0.15	0.21	0.26	0.31	0.36	0.41	5	7
6	5	0. 5	0.11	0.16	0.22	0.28	0.33	0.38	0.44	6	6
5	6	0. 6	0.12	0.17	0.24	0.30	0.35	0.41	0.47	7	5
4	7	0. 6	0.12	0.18	0.25	0.31	0.37	0.43	0.49	8	4
3	8	0. 6	0.13	0.19	0.26	0.33	0.39	0.45	0.52	9	3
2	9	0. 7	0.14	0.20	0.27	0.34	0.41	0.48	0.55	10	2
Decemb. 1	10	0. 7	0.14	0.21	0.29	0.36	0.43	0.50	0.57	11	1 June
Novemb. 30	11	0. 7	0.15	0.22	0.30	0.37	0.45	0.52	1. 0	12	31 May
29	12	0. 8	0.16	0.23	0.31	0.39	0.47	0.55	1. 3	13	30
28	13	0. 8	0.16	0.24	0.33	0.41	0.49	0.57	1. 6	14	29
27	14	0. 8	0.17	0.25	0.34	0.42	0.51	0.59	1. 8	15	28
26	15	0. 9	0.18	0.26	0.35	0.44	0.53	1. 2	1.11	16	27
25	16	0. 9	0.18	0.27	0.37	0.46	0.55	1. 4	1.13	17	26
24	17	0. 9	0.19	0.28	0.38	0.47	0.57	1. 6	1.16	18	25
23	18	0.10	0.20	0.29	0.39	0.49	0.58	1. 9	1.19	19	24
22	19	0.10	0.20	0.30	0.40	0.50	1. 0	1.10	1.20	20	23
21	20	0.10	0.21	0.31	0.41	0.51	1. 2	1.12	1.22	21	22
20	21	0.11	0.22	0.32	0.43	0.53	1. 4	1.14	1.25	22	21
19	22	0.11	0.22	0.33	0.44	0.55	1. 6	1.17	1.28	23	20
18	23	0.11	0.23	0.34	0.45	0.56	1. 7	1.19	1.30	24	19
17	24	0.12	0.23	0.34	0.46	0.57	1. 9	1.21	1.32	25	18
16	25	0.12	0.24	0.35	0.47	0.59	1.11	1.23	1.35	26	17
15	26	0.12	0.24	0.36	0.48	1. 0	1.12	1.24	1.36	27	16
14	27	0.12	0.25	0.37	0.49	1. 2	1.14	1.26	1.39	28	15
13	28	0.13	0.26	0.38	0.51	1. 4	1.16	1.28	1.41	29	14
11	January 30	0.13	0.26	0.39	0.53	1. 6	1.19	1.32	1.45	31 July	12
9	February 1	0.13	0.27	0.41	0.55	1. 9	1.22	1.36	1.50	2 August	10
7	3	0.14	0.28	0.42	0.57	1.11	1.25	1.39	1.53	4	8
5	5	0.14	0.29	0.43	0.58	1.13	1.27	1.42	1.56	6	6
3	7	0.15	0.30	0.45	1. 0	1.15	1.30	1.44	1.59	8	4
Novemb. 1	9	0.15	0.31	0.46	1. 2	1.17	1.32	1.47	2. 3	10	2 May
October 30	11	0.16	0.32	0.47	1. 3	1.19	1.35	1.50	2. 6	12	30 April
28	13	0.16	0.32	0.48	1. 5	1.21	1.37	1.53	2. 9	14	28
26	15	0.16	0.33	0.49	1. 6	1.22	1.39	1.56	2.12	16	26
24	17	0.17	0.34	0.50	1. 7	1.24	1.41	1.58	2.15	18	24
21	20	0.17	0.34	0.52	1. 9	1.27	1.44	2. 1	2.19	21	21
18	23	0.17	0.35	0.53	1.11	1.29	1.46	2. 4	2.22	24	18
15	February 26	0.18	0.36	0.54	1.13	1.31	1.49	2. 7	2.25	27	15
12	March 1	0.18	0.37	0.55	1.14	1.32	1.51	2. 9	2.28	30 August	12
9	4	0.19	0.38	0.56	1.15	1.34	1.53	2.12	2.30	2 Sept.	9
6	7	0.19	0.38	0.57	1.16	1.35	1.54	2.13	2.32	5	6
October 3	10	0.19	0.38	0.57	1.17	1.36	1.55	2.14	2.34	8	3 April
Septem. 30	13	0.19	0.39	0.58	1.17	1.37	1.56	2.15	2.35	11	31 March
27	16	0.19	0.39	0.53	1.18	1.38	1.57	2.16	2.36	14	28
24	19	0.20	0.39	0.53	1.18	1.38	1.57	2.16	2.36	17	25
After Equinox.	Before Equinox.	0.20	0.40	0.59	1.19	1.39	1.58	2.17	2.36	Before Equinox.	After Equinox.

Digitized by Google

TABLE V.

For reducing the Sun's Declination, as given in the Nautical Almanac for Noon at Greenwich, to any other Time under any other Meridian.

Add aft. N. Sub. bef. N. Add in W. Sub. in E. Days.	Sub. aft. N. Add bef. N. Sub. in W. Add in E. Days.	H.M 3. 0 45 Deg. M.S.	H.M 3. 20 50 Deg. M.S.	H.M 3. 40 55 Deg. M.S.	H.M 4. 0 60 Deg. M.S.	H.M 4. 20 65 Deg. M.S.	H.M 4. 40 70 Deg. M.S.	H.M 5. 0 75 Deg. M.S.	Sub. aft. N. Add bef. N. Sub. in W Add in E. Days.	Add aft. N. Sub. bef. N. Add in W. Sub. in E. Days
December 21	December 21	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	21 June	21 June
20	22	0. 3	0. 3	0. 4	0. 4	0. 4	0. 5	0. 5	22	20
19	23	0. 6	0. 7	0. 8	0. 9	0. 9	0.10	0.11	23	19
18	24	0.10	0.11	0.12	0.13	0.14	0.15	0.16	24	18
17	25	0.13	0.15	0.16	0.18	0.19	0.20	0.22	25	17
16	26	0.16	0.18	0.20	0.22	0.24	0.26	0.27	26	16
15	27	0.20	0.22	0.24	0.26	0.29	0.31	0.33	27	15
14	28	0.23	0.25	0.28	0.31	0.34	0.36	0.38	28	14
13	29	0.26	0.29	0.32	0.35	0.38	0.41	0.44	29	13
12	30	0.30	0.33	0.36	0.40	0.43	0.46	0.50	30 June	12
11	December 31	0.33	0.37	0.40	0.44	0.48	0.51	0.55	1 July	11
10	January 1	0.36	0.40	0.44	0.48	0.53	0.57	1. 1	2	10
9	2	0.39	0.44	0.48	0.53	0.57	1. 2	1. 6	3	9
8	3	0.43	0.48	0.53	0.57	1. 2	1. 7	1.11	4	8
7	4	0.46	0.51	0.56	1. 1	1. 7	1.12	1.17	5	7
6	5	0.49	0.55	1. 0	1. 6	1.11	1.17	1.22	6	6
5	6	0.52	0.58	1. 4	1.10	1.16	1.22	1.27	7	5
4	7	0.55	1. 1	1. 7	1.14	1.20	1.26	1.32	8	4
3	8	0.58	1. 5	1.11	1.18	1.24	1.31	1.37	9	3
2	9	1. 1	1. 8	1.15	1.22	1.29	1.36	1.43	10	2
December 1	10	1. 4	1.12	1.19	1.26	1.33	1.41	1.48	11	1 June
November 30	11	1. 7	1.15	1.23	1.30	1.37	1.45	1.52	12	31 May
29	12	1.10	1.18	1.26	1.34	1.42	1.50	1.57	13	30
28	13	1.13	1.22	1.30	1.38	1.46	1.54	2. 2	14	29
27	14	1.16	1.25	1.34	1.42	1.50	1.58	2. 7	15	28
26	15	1.19	1.28	1.37	1.46	1.55	2. 3	2.12	16	27
25	16	1.22	1.31	1.40	1.49	1.59	2. 8	2.17	17	26
24	17	1.25	1.35	1.44	1.53	2. 3	2.12	2.21	18	25
23	18	1.28	1.38	1.47	1.57	2. 7	2.16	2.26	19	24
22	19	1.30	1.41	1.51	2. 1	2.11	2.21	2.31	20	23
21	20	1.33	1.44	1.54	2. 4	2.15	2.25	2.35	21	22
20	21	1.36	1.47	1.57	2. 8	2.19	2.29	2.40	22	21
19	22	1.39	1.50	2. 0	2.11	2.22	2.33	2.44	23	20
18	23	1.41	1.53	2. 4	2.15	2.26	2.37	2.48	24	19
17	24	1.43	1.55	2. 7	2.18	2.30	2.41	2.52	25	18
16	25	1.46	1.58	2.10	2.21	2.33	2.45	2.56	26	17
15	26	1.48	2. 1	2.13	2.25	2.37	2.49	3. 1	27	16
14	27	1.51	2. 4	2.16	2.28	2.40	2.52	3. 5	28	15
13	28	1.54	2. 7	2.19	2.31	2.44	2.56	3. 9	29	14
11	January 30	1.58	2.11	2.24	2.37	2.51	3. 4	3.17	31 July	12
9	February 1	2. 3	2.17	2.30	2.43	2.57	3.11	3.24	2 August	10
7	3	2. 7	2.21	2.35	2.49	3. 3	3.17	3.32	4	8
5	5	2.11	2.25	2.40	2.54	3. 9	3.23	3.38	6	6
3	7	2.14	2.29	2.44	2.59	3.14	3.29	3.44	8	4
November 1	9	2.18	2.33	2.49	3. 4	3.19	3.35	3.50	10	2 May
October 30	11	2.22	2.38	2.53	3. 9	3.25	3.41	3.56	12	30 April
28	13	2.25	2.41	2.58	3.14	3.30	3.46	4. 3	14	28
26	15	2.29	2.45	3. 2	3.18	3.35	3.51	4. 8	16	26
24	17	2.32	2.49	3. 5	3.22	3.39	3.56	4.13	18	24
21	20	2.36	2.53	3.11	3.26	3.45	4. 3	4.20	21	21
18	23	2.40	2.58	3.15	3.33	3.51	4. 8	4.26	24	18
15	February 26	2.43	3. 1	3.20	3.38	3.56	4.14	4.32	27	15
12	March 1	2.46	3. 5	3.23	3.42	4. 1	4.19	4.38	30 August	12
9	4	2.49	3. 8	3.26	3.45	4. 4	4.23	4.41	2 Sept.	9
6	7	2.51	3.10	3.29	3.48	4. 7	4.26	4.45	5	6
October 3	10	2.53	3.13	3.32	3.51	4.10	4.29	4.49	8	3 April
September 30	13	2.55	3.14	3.33	3.53	4.13	4.32	4.51	11	31 March
27	16	2.56	3.15	3.34	3.54	4.14	4.33	4.52	14	28
24	19	2.56	3.15	3.35	3.55	4.15	4.33	4.52	17	25
After Equinox.	Before Equinox.	2.56	3.15	3.35	3.55	4.15	4.34	4.53	Before Equinox.	After Equinox.

Digitized by Google

TABLE V.

For reducing the Sun's Declination, as given in the Nautical Almanac for Noon at Greenwich, to any other Time under any other Meridian.

Add aft. N. Sub. bef. N.	Sub. aft. N. Add bef. N.	H.M 5. 20	H.M 5. 40	H.M 6. 0	H.M 6. 20	H.M 6. 40	H.M 7. 0	H.M 7. 20	Sub. aft. N. Add bef. N.	Add aft. N Sub. bef. N
Add in W. Sub. in E.	Sub. in W. Add in E.	80 Deg.	85 Deg.	90 Deg.	95 Deg.	100 Deg.	105 Deg.	110 Deg.	Sub. in W. Add in E.	Add in W Sub. in E
Days.	Days.	M.S.	M.S.	M.S.	M.S.	M.S.	M.S.	M.S.	Days.	Days.
December 21	December 21	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	21 June	21 June
20	22	0. 5	0. 6	0. 6	0. 7	0. 8	0. 8	0. 8	22	20
19	23	0.11	0.12	0.13	0.14	0.15	0.15	0.16	23	19
18	24	0.17	0.19	0.20	0.21	0.22	0.23	0.24	24	18
17	25	0.23	0.25	0.26	0.28	0.29	0.31	0.32	25	17
16	26	0.29	0.31	0.33	0.35	0.37	0.38	0.40	26	16
15	27	0.35	0.38	0.40	0.42	0.44	0.46	0.49	27	15
14	28	0.41	0.43	0.46	0.49	0.51	0.54	0.57	28	14
13	29	0.47	0.50	0.53	0.56	0.59	1. 2	1. 5	29	13
12	30	0.53	0.56	0.59	1. 3	1. 6	1. 9	1.12	30 June	12
11	December 31	0.59	1. 2	1. 6	1.10	1.13	1.17	1.21	1 July	11
10	January 1	1. 5	1. 9	1.13	1.17	1.21	1.25	1.29	2	10
9	2	1.11	1.15	1.19	1.24	1.28	1.32	1.37	3	9
8	3	1.16	1.21	1.26	1.[illegible]1	1.35	1.40	1.45	4	8
7	4	1.22	1.27	1.32	1.3[illegible]	1.42	1.47	1.53	5	7
6	5	1.27	1.33	1.38	1.44	1.49	1.54	2. 0	6	6
5	6	1.33	1.39	1.45	1.51	1.57	2. 2	2. 8	7	5
4	7	1.39	1.45	1.51	1.57	2. 3	2. 9	2.16	8	4
3	8	1.44	1.50	1.57	2. 4	2.10	2.16	2.23	9	3
2	9	1.50	1.56	2. 3	2.10	2.17	2.23	2.30	10	2
December 1	10	1.55	2. 2	2. 9	2.16	2.23	2.30	2.38	11	1 June
November 30	11	2. 0	2. 7	2.15	2.22	2.30	2.37	2.45	12	31 May
29	12	2. 5	2.13	2.21	2.29	2.37	2.44	2.52	13	30
28	13	2.10	2.19	2.27	2.35	2.43	2.51	3. 0	14	29
27	14	2.16	2.25	2.33	2.42	2.50	2.58	3. 7	15	28
26	15	2.21	2.30	2.38	2.47	2.56	3. 5	3.13	16	27
25	16	2.26	2.35	2.44	2.53	3. 2	3.11	3.21	17	26
24	17	2.31	2.40	2.50	2.59	3. 9	3.18	3.28	18	25
23	18	2.36	2.46	2.55	3. 5	3.15	3.24	3.34	19	24
22	19	2.41	2.51	3. 1	3.11	3.21	3.31	3.41	20	23
21	20	2.46	2.56	3. 6	3.17	3.27	3.37	3.48	21	22
20	21	2.50	3. 2	3.12	3.23	3.33	3.44	3.55	22	21
19	22	2.55	3. 6	3.17	3.28	3.39	3.50	4. 1	23	20
18	23	3. 0	3.11	3.22	3.33	3.45	3.56	4. 7	24	19
17	24	3. 4	3.16	3.27	3.39	3.50	4. 1	4.13	25	18
16	25	3. 8	3.20	3.32	3.44	3.56	4. 7	4.19	26	17
15	26	3.13	3.25	3.37	3.49	4. 1	4.13	4.26	27	16
14	27	3.17	3.29	3.42	3.54	4. 6	4.19	4.31	28	15
13	28	3.22	3.34	3.47	4. 0	4.12	4.25	4.38	29	14
11	January 30	3.30	3.43	3.56	4. 9	4.22	4.36	4.49	31 July	12
9	February 1	3.38	3.51	4. 5	4.18	4.32	4.46	4.59	2 August	10
7	3	3.46	4. 0	4.14	4.28	4.42	4.56	5.10	4	8
5	5	3.52	4. 6	4.21	4.36	4.50	5. 5	5.19	6	6
3	7	3.59	4.14	4.29	4.44	4.59	5.14	5.29	8	4
November 1	9	4. 5	4.21	4.36	4.52	5. 7	5.23	5.38	10	2 May
October 30	11	4.12	4.28	4.44	5. 0	5.16	5.31	5.47	12	30 April
28	13	4.19	4.35	4.51	5. 7	5.23	5.40	5.56	14	28
26	15	4.24	4.41	4.57	5.14	5.30	5.47	6. 3	16	26
24	17	4.30	4.47	5. 3	5.21	5.38	5.55	6.12	18	24
21	20	4.37	4.55	5.12	5.29	5.47	6. 4	6.21	21	21
18	23	4.44	5. 2	5.19	5.37	5.55	6.13	6.31	24	18
15	February 26	4.50	5. 8	5.26	5.44	6. 2	6.20	6.38	27	15
12	March 1	4.56	5.15	5.33	5.52	6.10	6.29	6.47	30 August	12
9	4	5. 0	5.19	5.38	5.57	6.16	6.34	6.53	2 Sept.	9
6	7	5. 4	5.23	5.42	6. 1	6.20	6.39	6.58	5	6
October 3	10	5. 8	5.27	5.46	6. 5	6.25	6.44	7. 3	8	3 April
September 30	13	5.11	5.30	5.49	6. 8	6.28	6.47	7. 6	11	31 March
27	16	5.12	5.31	5.51	6.11	6.31	6.50	7. 9	14	28
24	19	5.12	5.32	5.52	6.12	6.32	6.51	7.11	17	25
After Equinox.	Before Equinox.	5.13	5.33	5.53	6.13	6.33	6.52	7.11	Before Equinox.	After Equinox.

Digitized by Google

TABLE V.

For reducing the Sun's Declination, as given in the Nautical Almanac for Noon at Greenwich, to any other Time under any other Meridian.

Add aft. N. Sub. bef. N.	Sub. aft. N. Add bef. N.	H.M 7. 40	H.M 8. 0	H.M 8. 20	H.M 8. 40	H.M 9. 0	H.M 9. 20	H.M 9. 40	Sub. aft. N. Add bef. N.	Add aft. N. Sub. bef. N.
Add in W. Sub. in E.	Sub. in W. Add in E.	115 Deg.	120 Deg.	125 Deg.	130 Deg.	135 Deg.	140 Deg.	145 Deg.	Sub. in W. Add in E.	Add in W. Sub. in E.
Days.	Days.	M.S.	M.S.	M.S.	M.S.	M.S.	M.S.	M.S.	Days.	Days.
December 21	December 21	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	21 June	21 June
20	22	0. 9	0. 9	0. 9	0.10	0.10	0.10	0.10	22	20
19	23	0.17	0.18	0.18	0.19	0.19	0.20	0.21	23	19
18	24	0.25	0.26	0.27	0.28	0.29	0.30	0.31	24	18
17	25	0.34	0.35	0.36	0.38	0.39	0.41	0.43	25	17
16	26	0.42	0.44	0.46	0.48	0.49	0.51	0.53	26	16
15	27	0.51	0.53	0.55	0.57	0.59	1. 1	1. 3	27	15
14	28	0.59	1. 2	1. 5	1. 7	1. 9	1.12	1.14	28	14
13	29	1. 8	1.11	1.14	1.17	1.19	1.22	1.25	29	13
12	30	1.16	1.19	1.23	1.26	1.29	1.32	1.35	30 June	12
11	December 31	1.24	1.28	1.32	1.35	1.39	1.43	1.46	1 July	11
10	January 1	1.33	1.37	1.41	1.45	1.49	1.53	1.57	2	10
9	2	1.42	1.46	1.51	1.55	1.59	2. 3	2. 7	3	9
8	3	1.49	1.54	1.59	2. 4	2. 9	2.13	2.18	4	8
7	4	1.58	2. 3	2. 8	2.13	2.19	2.23	2.28	5	7
6	5	2. 5	2.11	2.16	2.22	2.28	2.33	2.39	6	6
5	6	2.14	2.20	2.26	2.32	2.38	2.43	2.49	7	5
4	7	2.22	2.28	2.34	2.41	2.47	2.53	2.59	8	4
3	8	2.29	2.36	2.43	2.49	2.56	3. 3	3. 9	9	3
2	9	2.37	2.44	2.51	2.58	3. 5	3.12	3.19	10	2
December 1	10	2.45	2.52	2.59	3. 6	3.14	3.21	3.28	11	1 June
November 30	11	2.52	3. 0	3. 7	3.15	3.23	3.30	3.38	12	31 May
29	12	3. 0	3. 8	3.16	3.24	3.32	3.39	3.47	13	30
28	13	3. 8	3.16	3.24	3.32	3.40	3.49	3.57	14	29
27	14	3.15	3.24	3.32	3.41	3.49	3.58	4. 6	15	28
26	15	3.22	3.31	3.40	3.49	3.58	4. 7	4.16	16	27
25	16	3.30	3.39	3.48	3.57	4. 7	4.16	4.25	17	26
24	17	3.37	3.46	3.56	4. 6	4.16	4.24	4.34	18	25
23	18	3.44	3.54	4. 4	4.14	4.24	4.33	4.43	19	24
22	19	3.51	4. 1	4.11	4.21	4.31	4.41	4.51	20	23
21	20	3.58	4. 8	4.19	4.29	4.39	4.50	5. 0	21	22
20	21	4. 5	4.16	4.27	4.37	4.48	4.59	5. 9	22	21
19	22	4.12	4.23	4.34	4.45	4.56	5. 7	5.18	23	20
18	23	4.19	4.30	4.41	4.53	5. 4	5.15	5.26	24	19
17	24	4.25	4.36	4.48	5. 0	5.12	5.23	5.34	25	18
16	25	4.31	4.43	4.55	5. 7	5.19	5.30	5.42	26	17
15	26	4.38	4.50	5. 2	5.14	5.26	5.38	5.50	27	16
14	27	4.43	4.56	5. 8	5.21	5.33	5.46	5.58	28	15
13	28	4.50	5. 3	5.16	5.28	5.40	5.54	6. 6	29	14
11	January 30	5. 2	5.15	5.28	5.41	5.54	6. 8	6.21	31 July	12
9	February 1	5.13	5.27	5.40	5.54	6. 8	6.22	6.35	2 August	10
7	3	5.24	5.38	5.52	6. 6	6.20	6.35	6.49	4	8
5	5	5.34	5.49	6. 4	6.18	6.33	6.47	7. 2	6	6
3	7	5.44	5.59	6.14	6.29	6.44	6.59	7.14	8	4
November 1	9	5.53	6. 9	6.24	6.40	6.55	7.11	7.26	10	2 May
October 30	11	6. 3	6.18	6.34	6.50	7. 6	7.21	7.37	12	30 April
28	13	6.12	6.28	6.44	7. 0	7.16	7.32	7.48	14	28
26	15	6.20	6.36	6.53	7.10	7.26	7.42	7.58	16	26
24	17	6.29	6.45	7. 2	7.19	7.36	7.52	8. 9	18	24
21	20	6.39	6.56	7.13	7.31	7.48	8. 5	8.22	21	21
18	23	6.48	7. 6	7.24	7.42	8. 0	8.17	8.34	24	18
15	February 26	6.57	7.15	7.34	7.52	8.10	8.28	8.46	27	15
12	March 1	7. 6	7.24	7.42	8. 1	8.20	8.38	8.57	30 August	12
9	4	7.12	7.31	7.50	8. 9	8.28	8.46	9. 6	2 Sept.	9
6	7	7.17	7.36	7.55	8.14	8.33	8.53	9.12	5	6
October 3	10	7.23	7.42	8. 1	8.20	8.39	8.59	9.18	8	3 April
September 30	13	7.26	7.45	8. 4	8.24	8.43	9. 3	9.22	11	31 March
27	16	7.29	7.48	8. 7	8.27	8.47	9. 6	9.25	14	28
24	19	7.30	7.50	8.10	8.29	8.49	9. 8	9.27	17	25
After Equinox.	Before Equinox.	7.31	7.50	8.10	8.30	8.50	9. 9	9.28	Before Equinox.	After Equinox.

Digitized by Google

TABLE V.

For reducing the Sun's Declination, as given in the Nautical Almanac for Noon at Greenwich, to any other Time under any other Meridian.

Add aft. N. Sub. bef. N.	Sub. aft. N. Add bef. N.	H. M. 10 0	H. M. 10. 20	H. M. 10. 40	H. M. 11. 0	H. M. 11. 20	H. M. 11. 40	H. M. 12. 0	Sub. aft. N. Add bef. N.	Add aft. N. Sub. bef. N.
Add in W. Sub. in E.	Sub. in W. Add in E.	150 Deg.	155 Deg.	160 Deg.	165 Deg.	170 Deg.	175 Deg.	180 Deg.	Sub. in W. Add in E.	Add in W. Sub. in E.
Days.	Days.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	M. S.	Days.	Days.
Decemb. 21	Decemb. 21	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	21 June	21 June
20	22	0.11	0.11	0.12	0.12	0.12	0.13	0.13	22	20
19	23	0.22	0.23	0.24	0.24	0.25	0.26	0.26	23	19
18	24	0.33	0.34	0.35	0.36	0.37	0.38	0.39	24	18
17	25	0.44	0.46	0.47	0.48	0.50	0.51	0.53	25	17
16	26	0.55	0.57	0.58	1. 0	1. 2	1. 4	1. 6	26	16
15	27	1. 6	1. 8	1.11	1.13	1.15	1.17	1.19	27	15
14	28	1.17	1.20	1.23	1.25	1.27	1.30	1.32	28	14
13	29	1.28	1.31	1.34	1.37	1.40	1.43	1.46	29	13
12	30	1.39	1.42	1.45	1.49	1.52	1.55	1.59	30 June	12
11	Decemb. 31	1.50	1.54	1.57	2. 1	2. 5	2. 8	2.12	1 July	11
10	January 1	2. 1	2. 5	2. 9	2 13	2.17	2.21	2.25	2	10
9	2	2.12	2.16	2.20	2.25	2.30	2.34	2.38	3	9
8	3	2.23	2.27	2.32	2.37	2.42	2.47	2.51	4	8
7	4	2.34	2.39	2.44	2.49	2.54	2.59	3. 4	5	7
6	5	2.44	2.50	2.55	3. 0	3. 6	3.12	3.17	6	6
5	6	2.55	3. 1	3. 6	3.12	3.18	3.24	3.30	7	5
4	7	3. 5	3.11	3.17	3.23	3.29	3.36	3.42	8	4
3	8	3.15	3.21	3.28	3.34	3.41	3.48	3.54	9	3
2	9	3.25	3.32	3.38	3.45	3.52	3.59	4. 6	10	2
Decemb. 1	10	3.35	3.42	3.49	3.56	4. 4	4.11	4.18	11	1 June
Novemb. 30	11	3.45	3.52	3.59	4. 7	4.15	4.22	4.30	12	31 May
29	12	3.55	4. 3	4.10	4.18	4.26	4.34	4.42	13	30
28	13	4. 5	4.13	4.21	4.29	4.38	4.46	4.54	14	29
27	14	4.15	4.23	4.31	4.40	4.49	4.57	5. 5	15	28
26	15	4.24	4.33	4.41	4.50	4.59	5. 8	5.17	16	27
25	16	4.34	4.43	4.52	5. 1	5.10	5.19	5.28	17	26
24	17	4.43	4.53	5. 2	5.11	5.21	5.30	5.40	18	25
23	18	4.52	5. 2	5.12	5.22	5.32	5.41	5.51	19	24
22	19	5. 1	5.12	5.22	5.32	5.42	5.52	6. 2	20	23
21	20	5.10	5.21	5.31	5.42	5.53	6. 3	6.13	21	22
20	21	5.20	5.31	5.41	5.52	6. 3	6.14	6.24	22	21
19	22	5.29	5.40	5.51	6. 2	6.13	6.24	6.34	23	20
18	23	5.37	5.49	6. 0	6.11	6.23	6.34	6.44	24	19
17	24	5.45	5.57	6. 9	6.20	6.32	6.43	6.54	25	18
16	25	5.54	6. 6	6.17	6.29	6.41	6.53	7. 4	26	17
15	26	6. 2	6.14	6.26	6.38	6.51	7. 3	7.14	27	16
14	27	6.10	6.22	6.34	6.47	7. 0	7.12	7.24	28	15
13	28	6.19	6.31	6.43	6.56	7. 9	7.22	7.34	29	14
11	January 30	6.34	6.47	7. 0	7.13	7.26	7.40	7.53	31 July	12
9	February 1	6.49	7. 3	7.16	7.30	7.43	7.57	8.11	2 August	10
7	3	7. 3	7.17	7.31	7.45	7.59	8.13	8.28	4	8
5	5	7.16	7.31	7.45	8. 0	8.14	8.28	8.43	6	6
3	7	7.29	7.44	7.59	8.14	8.28	8.43	8.58	8	4
Novemb. 1	9	7.41	7.56	8.12	8.27	8.42	8.58	9.13	10	2 May
October 30	11	7.53	8. 8	8.24	8.40	8.56	9.12	9.28	12	30 April
28	13	8. 4	8.20	8.36	8.53	9. 9	9.25	9.42	14	28
26	15	8.15	8.32	8.48	9. 5	9.21	9.38	9.54	16	26
24	17	8.26	8.43	9. 0	9.17	9.34	9.50	10. 7	18	24
21	20	8.40	8.57	9.14	9.32	9.49	10. 6	10.24	21	21
18	23	8.52	9.10	9.28	9.46	10. 3	10.21	10.39	24	18
15	February 26	9. 4	9.22	9.40	9.58	10.16	10.34	10.53	27	15
12	March 1	9.15	9.33	9.51	10.10	10.29	10.47	11. 6	30 August	12
9	4	9.24	9.43	10. 1	10.20	10.39	10.58	11.16	2 Sept.	9
6	7	9.30	9.50	10. 9	10.28	10.47	11. 6	11.24	5	6
October 3	10	9.37	9.56	10.16	10.35	10.54	11.13	11.32	8	3 April
Septem. 30	13	9.41	10. 0	10.21	10.40	10.59	11.18	11.38	11	31 March
27	16	9.45	10 4	10.24	10.44	11. 3	11.22	11.42	14	28
24	19	9.47	10. 6	10.26	10.46	11. 5	11.24	11.44	17	25
After Equinox.	Before Equinox.	9.48	10. 7	10.27	10.47	11. 6	11.25	11.45	Before Equinox.	After Equinox.

Digitized by Google

TABLE VI.

Sun's Right Ascension.

Days.	JAN.	FEB.	MAR.	APR.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	Days.
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	
1	18.46	20.58	22.48	0.42	2.33	4.36	6.40	8.45	10.41	12.29	14.25	16.29	1
2	18.50	21. 2	22.52	0.46	2.37	4.40	6.44	8.49	10.45	12.33	14.29	16.33	2
3	18.55	21. 6	22.56	0.49	2.41	4.44	6.48	8.53	10.48	12.36	14.33	16.38	3
4	18.59	21.10	23.00	0.53	2.45	4.48	6.53	8.57	10.52	12.40	14.37	16.42	4
5	19. 4	21.14	23. 3	0.57	2.48	4.52	6.57	9. 0	10.56	12.44	14.41	16.47	5
6	19. 8	21.19	23. 7	1. 0	2.52	4.56	7. 1	9. 4	10.59	12.47	14.45	16.51	6
7	19.12	21.23	23.11	1. 4	2.56	5. 1	7. 5	9. 8	11. 3	12.51	14.49	16.55	7
8	19.17	21.27	23.14	1. 7	3. 0	5. 5	7. 9	9.12	11. 6	12.55	14.53	17. 0	8
9	19.21	21.30	23.18	1.11	3. 4	5. 9	7.13	9.16	11.10	12.58	14.57	17. 4	9
10	19.25	21.34	23.22	1.15	3. 8	5.13	7.17	9.20	11.14	13. 2	15. 1	17. 8	10
11	19.30	21.38	23.25	1.18	3.12	5.17	7.21	9.23	11.17	13. 6	15. 5	17.13	11
12	19.34	21.42	23.29	1.22	3.16	5.21	7.25	9.27	11:21	13. 9	15. 9	17.17	12
13	19.38	21.46	23.33	1.26	3.20	5.25	7.29	9.31	11.24	13.13	15.13	17.22	13
14	19.43	21.50	23.36	1.30	3.24	5.29	7.33	9.35	11.28	13.17	15.17	17.26	14
15	19.47	21.54	23.40	1.33	3.27	5.34	7.37	9.38	11.32	13.21	15.22	17.31	15
16	19.51	21.58	23.44	1.37	3.31	5.38	7.41	9.42	11.35	13.24	15.26	17.35	16
17	19.56	22. 2	23.47	1.41	3.35	5.42	7.46	9.46	11.39	13.28	15.30	17.39	17
18	20. 0	22. 6	23.51	1.44	3.39	5.46	7.50	9.50	11.42	13.32	15.34	17.44	18
19	20. 4	22.10	23.55	1.48	3.43	5.50	7.54	9.53	11.46	13.35	15.38	17.48	19
20	20. 8	22.13	23.58	1.52	3.47	5.54	7.58	9.57	11.50	13.39	15.42	17.53	20
21	20.13	22.17	0. 2	1.55	3.51	5.59	8. 2	10. 1	11.53	13.43	15.47	17.57	21
22	20.17	22.21	0. 6	1.59	3.55	6. 3	8. 6	10. 4	11.57	13.47	15.51	18. 2	22
23	20.21	22.25	0. 9	2. 3	3.59	6. 7	8.10	10. 8	12. 0	13.51	15.55	18. 6	23
24	20.25	22.29	0.13	2. 7	4. 3	6.11	8.14	10.12	12. 4	13.54	15.59	18.10	24
25	20.29	22.32	0.17	2.10	4. 7	6.15	8.18	10.16	12. 7	13.58	16. 3	18.15	25
26	20.34	22.36	0.20	2.14	4.11	6.19	8.21	10.19	12.11	14. 2	16. 8	18.19	26
27	20.38	22.40	0.24	2.18	4.15	6.24	8.25	10.23	12.15	14. 6	16.12	18.24	27
28	20.42	22.44	0.27	2.22	4.20	6.28	8.29	10.27	12.18	14.10	16.16	18.28	28
29	20.46	22.46	0.31	2.26	4.24	6.32	8.33	10.30	12.22	14.14	16.21	18.33	29
30	20.50		0.35	2.29	4.28	6.36	8.37	10.34	12.26	14.18	16.25	18.37	30
31	20.54		0.38		4.32		8.41	10.37		14.21		18.42	31

This Table gives nearly the Sun's Right Ascension for the years 1833, 1834, 1835, and 1836, and is sufficiently exact for finding when any Star comes to the meridian. But in all calculations for determining the longitude by celestial observations, the Sun's Right Ascension must be taken from the Nautical Almanac, where it is calculated to a greater degree of accuracy.

TABLE VI. A.

Correction for the daily variation of the Equation of Time found in TABLE IV. A.
Find the daily variation of Equation of Time at the top, the hour at Greenwich at the side.

Hour.	" 1	" 2	" 3	" 4	" 5	" 6	" 7	" 8	" 9	" 10	" 11	" 12	" 13	" 14	" 15	" 16	" 17	" 18	" 19	" 20	" 21	" 22	" 23	" 24	" 25	" 26	" 27	" 28	" 29	" 30	Deg.
1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
2	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	3	30
3	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	4	4	4	45
4	0	0	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	4	4	4	4	4	4	5	5	5	5	60
5	0	0	1	1	1	1	1	2	2	2	2	3	3	3	3	3	4	4	4	4	4	5	5	5	5	5	6	6	6	6	75
6	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6	6	7	7	7	7	8	90
7	0	1	1	1	1	2	2	2	3	3	3	4	4	4	4	5	5	5	6	6	6	6	7	7	7	8	8	8	8	9	105
8	0	1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9	10	10	120
9	0	1	1	2	2	2	3	3	3	4	4	5	5	5	6	6	6	7	7	8	8	8	9	9	9	10	10	11	11	11	135
10	0	1	1	2	2	3	3	3	4	4	5	5	5	6	6	7	7	8	8	8	9	9	10	10	10	11	11	12	12	13	150
11	0	1	1	2	2	3	3	4	4	5	5	6	6	6	7	7	8	8	9	9	10	10	11	11	11	12	12	13	13	14	165
12	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	180
13	1	1	2	2	3	3	4	4	5	5	6	7	7	8	8	9	9	10	10	11	11	12	12	13	14	14	15	15	16	16	195
14	1	1	2	2	3	4	4	5	5	6	6	7	8	8	9	9	10	11	11	12	12	13	13	14	15	15	16	16	17	18	210
15	1	1	2	3	3	4	4	5	6	6	7	8	8	9	9	10	11	11	12	13	13	14	14	15	16	16	17	18	18	19	225
16	1	1	2	3	3	4	5	5	6	7	7	8	9	9	10	11	11	12	13	13	14	15	15	16	17	17	18	19	19	20	240
17	1	1	2	3	4	4	5	6	6	7	8	9	9	10	11	11	12	13	13	14	15	16	16	17	18	18	19	20	21	21	255
18	1	2	2	3	4	5	5	6	7	8	8	9	10	11	11	12	13	14	14	15	16	17	17	18	19	20	20	21	22	23	270
19	1	2	2	3	4	5	6	6	7	8	9	10	10	11	12	13	13	14	15	16	17	17	18	19	20	21	21	22	23	24	285
20	1	2	3	3	4	5	6	7	8	8	9	10	11	12	13	13	14	15	16	17	18	18	19	20	21	22	23	23	24	25	300
21	1	2	3	4	4	5	6	7	3	9	10	11	11	12	13	14	15	16	17	18	18	19	20	21	22	23	24	25	25	26	315
22	1	2	3	4	5	6	6	7	8	9	10	11	12	13	14	15	16	17	17	18	19	20	21	22	23	24	25	26	27	28	330
23	1	2	3	4	5	6	7	8	9	10	11	12	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	345
24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	360

Digitized by Google

TABLE VII.

Amplitudes.

DECLINATION.

Lat.	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	23° 28'	Lat.
	D.M.	D.M.	D.M.	D.M.	D.M.	D.M.	D.M.	D.M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	
1°	1. 0	2. 0	3. 0	4. 0	5. 0	6. 0	7. 0	8. 0	9. 0	10. 0	11. 0	12. 0	13. 0	14. 0	15. 0	16. 0	17. 0	18. 0	19. 0	20. 0	21. 0	22. 0	23. 0	23.28	1°
2	1. 0	2. 0	3. 0	4. 0	5. 0	6. 0	7. 0	8. 0	9. 0	10. 0	11. 0	12. 0	13. 0	14. 1	15. 1	16. 1	17. 1	18. 1	19. 1	20. 1	21. 1	22. 1	23. 1	23.29	2
3	1. 0	2. 0	3. 0	4. 0	5. 0	6. 0	7. 1	8. 1	9. 1	10. 1	11. 1	12. 1	13. 1	14. 1	15. 1	16. 1	17. 1	18. 2	19. 2	20. 2	21. 2	22. 2	23. 2	23.30	3
4	1. 0	2. 0	3. 0	4. 1	5. 1	6. 1	7. 1	8. 1	9. 1	10. 1	11. 2	12. 2	13. 2	14. 2	15. 2	16. 2	17. 3	18. 3	19. 3	20. 3	21. 3	22. 3	23. 4	23.32	4
5	1. 0	2. 0	3. 1	4. 1	5. 1	6. 1	7. 2	8. 2	9. 2	10. 2	11. 3	12. 3	13. 3	14. 3	15. 4	16. 4	17. 4	18. 4	19. 5	20. 5	21. 5	22. 5	23. 6	23.34	5
6	1. 0	2. 1	3. 1	4. 1	5. 2	6. 2	7. 2	8. 3	9. 3	10. 3	11. 4	12. 4	13. 4	14. 5	15. 5	16. 5	17. 6	18. 6	19. 7	20. 7	21. 7	22. 8	23. 8	23.36	6
7	1. 0	2. 1	3. 1	4. 2	5. 2	6. 3	7. 3	8. 4	9. 4	10. 5	11. 5	12. 5	13. 6	14. 6	15. 7	16. 7	17. 8	18. 8	19. 9	20. 9	21.10	22.10	23.11	23.39	7
8	1. 1	2. 1	3. 2	4. 2	5. 3	6. 4	7. 4	8. 5	9. 5	10. 6	11. 7	12. 7	13. 8	14. 8	15. 9	16.10	17.10	18.11	19.12	20.12	21.13	22.14	23.14	23.43	8
9	1. 1	2. 1	3. 2	4. 3	5. 4	6. 5	7. 5	8. 6	9. 7	10. 8	11. 8	12. 9	13.10	14.11	15.11	16.12	17.13	18.14	19.15	20.16	21.16	22.17	23.18	23.47	9
10	1. 1	2. 2	3. 3	4. 4	5. 5	6. 6	7. 7	8. 7	9. 8	10. 9	11.10	12.11	13.12	14.13	15.14	16.15	17.16	18.17	19.18	20.19	21.20	22.21	23.23	23.51	10
11	1. 1	2. 2	3. 3	4. 4	5. 6	6. 7	7. 8	8. 9	9.10	10.11	11.13	12.14	13.15	14.16	15.17	16.18	17.20	18.21	19.22	20.23	21.25	22.26	23.27	23.56	11
12	1. 1	2. 3	3. 4	4. 5	5. 7	6. 8	7. 9	8.11	9.12	10.14	11.15	12.16	13.18	14.19	15.21	16.22	17.24	18.25	19.26	20.28	21.30	22.31	23.33	24. 1	12
13	1. 2	2. 3	3. 5	4. 6	5. 8	6.10	7.11	8.13	9.14	10.16	11.18	12.19	13.21	14.23	15.24	16.26	17.28	18.29	19.31	20.33	21.35	22.37	23.38	24. 7	13
14	1. 2	2. 4	3. 6	4. 7	5. 9	6.11	7.13	8.15	9.17	10.19	11.20	12.22	13.24	14.26	15.28	16.30	17.32	18.34	19.36	20.38	21.40	22.43	23.45	24.14	14
15	1. 2	2. 4	3. 6	4. 8	5.11	6.13	7.15	8.17	9.19	10.21	11.24	12.26	13.28	14.30	15.33	16.35	17.37	18.39	19.42	20.44	21.47	22.49	23.52	24.21	15
16	1. 2	2. 5	3. 7	4.10	5.12	6.15	7.17	8.19	9.22	10.24	11.27	12.29	13.32	14.35	15.37	16.40	17.42	18.45	19.48	20.51	21.53	22.56	23.59	24.28	16
17	1. 3	2. 5	3. 8	4.11	5.14	6.17	7.19	8.22	9.25	10.28	11.31	12.33	13.36	14.39	15.42	16.45	17.48	18.51	19.54	20.57	22. 1	23. 4	24. 7	24.36	17
18	1. 3	2. 6	3. 9	4.12	5.15	6.19	7.22	8.25	9.28	10.31	11.34	12.38	13.41	14.44	15.47	16.51	17.54	18.58	20. 1	21. 5	22. 8	23.12	24.15	24.45	18
19	1. 3	2. 7	3.10	4.14	5.17	6.21	7.24	8.28	9.31	10.35	11.39	12.42	13.46	14.49	15.53	16.57	18. 1	19. 5	20. 8	21.12	22.16	23.20	24.25	24.54	19
20	1. 4	2. 8	3.12	4.15	5.19	6.23	7.27	8.31	9.35	10.39	11.43	12.47	13.51	14.55	15.59	17. 3	18. 8	19.12	20.16	21.21	22.25	23.30	24.34	25. 4	20
21	1. 4	2. 9	3.13	4.17	5.21	6.26	7.30	8.34	9.39	10.43	11.48	12.52	13.57	15. 1	16. 6	17.10	18.15	19.20	20.25	21.29	22.34	23.39	24.45	25.15	21
22	1. 5	2. 9	3.14	4.19	5.24	6.28	7.33	8.38	9.43	10.48	11.53	12.57	14. 2	15. 7	16.13	17.18	18.23	19.28	20.33	21.39	22.44	23.50	24.55	25.26	22
23	1. 5	2.10	3.16	4.21	5.26	6.31	7.36	8.42	9.47	10.52	11.58	13. 3	14. 9	15.14	16.20	17.25	18.31	19.37	20.43	21.49	22.55	24. 1	25. 7	25.38	23
24	1. 6	2.11	3.17	4.23	5.28	6.34	7.40	8.46	9.52	10.57	12. 3	13. 9	14.15	15.21	16.27	17.34	18.40	19.46	20.53	21.59	23. 6	24.13	25.19	25.51	24
25	1. 6	2.12	3.19	4.25	5.31	6.37	7.44	8.50	9.56	11. 3	12. 9	13.16	14.22	15.29	16.36	17.42	18.49	19.56	21. 3	22.10	23.18	24.25	25.32	26. 4	25
26	1. 7	2.14	3.20	4.27	5.34	6.41	7.48	8.54	10. 1	11. 8	12.15	13.22	14.30	15.37	16.44	17.52	18.59	20. 7	21.14	22.22	23.30	24.38	25.46	26.18	26
27	1. 7	2.15	3.22	4.29	5.37	6.44	7.52	8.59	10. 7	11.14	12.22	13.30	14.37	15.45	16.53	18. 1	19. 9	20.18	21.26	22.34	23.43	24.52	26. 1	26.33	27
28	1. 8	2.16	3.24	4.32	5.40	6.48	7.56	9. 4	10.12	11.21	12.29	13.37	14.46	15.54	17. 3	18.11	19.20	20.29	21.38	22.47	23.57	25. 6	26.16	26.48	28
29	1. 9	2.17	3.26	4.34	5.43	6.52	8. 1	9. 9	10.18	11.27	12.36	13.45	14.54	16. 3	17.13	18.22	19.32	20.41	21.51	23. 1	24.11	25.22	26.32	27. 5	29
30	1. 9	2.19	3.28	4.37	5.47	6.56	8. 5	9.15	10.24	11.34	12.44	13.53	15. 3	16.13	17.23	18.34	19.44	20.54	22. 5	23.15	24.27	25.38	26.49	27.23	30
31	1.10	2.20	3.30	4.40	5.50	7. 0	8.10	9.21	10.31	11.41	12.52	14. 2	15.13	16.24	17.34	18.45	19.57	21. 8	22.19	23.31	24.43	25.55	27. 7	27.41	31
32	1.11	2.22	3.32	4.43	5.54	7. 5	8.16	9.27	10.38	11.49	13. 0	14.11	15.23	16.34	17.46	18.58	20.10	21.22	22.35	23.47	25. 0	26.13	27.26	28. 0	32
33	1.12	2.23	3.35	4.46	5.58	7.10	8.21	9.33	10.45	11.57	13. 9	14.21	15.34	16.46	17.59	19.11	20.24	21.37	22.51	24. 4	25.18	26.32	27.46	28.21	33

Digitized by Google

TABLE VII

Amplitudes.

DECLINATION.

Lat.	1° D.M.	2° D.M.	3° D.M.	4° D.M.	5° D. M.	6° D. M.	7° D. M.	8° D. M.	9° D. M.	10° D. M.	11° D. M.	12° D. M.	13° D. M.	14° D. M.	15° D. M.	16° D. M.	17° D. M.	18° D. M.	19° D. M.	20° D. M.	21° D. M.	22° D. M.	23° D. M.	23° 28′ D. M.	Lat.
34°	1.12	2.25	3.37	4.50	6. 2	7.15	8.27	9.40	10.53	12. 5	13.18	14.31	15.45	16.58	18.11	19.25	20.39	21.53	23. 7	24.22	25.37	26.52	28. 7	28.42	34°
35	1.13	2.27	3.40	4.53	6. 6	7.20	8.33	9.47	11. 1	12.14	13.28	14.42	15.56	17.11	18.25	19.40	20.55	22.10	23.25	24.41	25.57	27.13	28.29	29. 5	35
36	1.14	2.28	3.43	4.57	6.11	7.25	8.40	9.54	11. 9	12.24	13.39	14.54	16. 9	17.24	18.39	19.55	21.11	22.27	23.44	25. 1	26.18	27.35	28.53	29.29	36
37	1.15	2.30	3.45	5. 1	6.16	7.31	8.47	10. 2	11.18	12.33	13.49	15. 5	16.22	17.38	18.55	20.11	21.28	22.46	24. 3	25.21	26.40	27.58	29.17	29.55	37
38	1.16	2.32	3.48	5. 5	6.21	7.37	8.54	10.10	11.27	12.44	14. 1	15.18	16.35	17.53	19.10	20.28	21.47	23. 5	24.24	25.43	27. 3	28.23	29.44	30.21	38
39	1.17	2.34	3.52	5. 9	6.26	7.44	9. 1	10.19	11.37	12.55	14.13	15.31	16.50	18. 8	19.27	20.46	22. 6	23.26	24.46	26. 7	27.28	28.49	30.11	30.49	39
40	1.18	2.37	3.55	5.13	6.32	7.51	9. 9	10.28	11.47	13. 6	14.25	15.45	17. 5	18.25	19.45	21. 5	22.26	23.47	25. 9	26.31	27.54	29.17	30.40	31.19	40
41	1.20	2.39	3.59	5.18	6.38	7.58	9.18	10.38	11.58	13.18	14.39	15.59	17.20	18.42	20. 3	21.25	22.48	24.10	25.33	26.57	28.21	29.46	31.11	31.51	41
42	1.21	2.42	4. 2	5.23	6.44	8. 5	9.26	10.48	12. 9	13.31	14.53	16.15	17.37	19. 0	20.23	21.46	23.10	24.34	25.59	27.24	28.50	30.16	31.43	32.24	42
43	1.22	2.44	4. 6	5.28	6.51	8.13	9.36	10.58	12.21	13.44	15. 7	16.31	17.55	19.19	20.44	22. 8	23.34	25.00	26.26	27.53	29.20	30.49	32.18	32.59	43
44	1.23	2.47	4.10	5.34	6.58	8.21	9.45	11. 9	12.34	13.58	15.23	16.48	18.13	19.39	21. 5	22.32	23.59	25.26	26.55	28.23	29.53	31.23	32.54	33.37	44
45	1.25	2.50	4.15	5.40	7. 5	8.30	9.55	11.21	12.47	14.13	15.39	17. 6	18.33	20.00	21.28	22.57	24.25	25.55	27.25	28.56	30.27	31.59	33.33	34.16	45
46	1.26	2.53	4.19	5.46	7.12	8.39	10. 6	11.33	13. 1	14.29	15.57	17.25	18.54	20.23	21.53	23.23	24.53	26.25	27.57	29.30	31. 3	32.38	34.14	34.59	46
47	1.28	2.56	4.24	5.52	7.21	8.49	10.18	11.46	13.16	14.45	16.15	17.45	19.16	20.47	22.18	23.50	25.23	26.57	28.31	30. 6	31.42	33.19	34.57	35.43	47
48	1.30	2.59	4.29	5.59	7.29	8.59	10.30	12. 0	13.31	15. 2	16.34	18. 6	19.39	21.12	22.45	24.20	25.55	27.30	29. 7	30.44	32.23	34. 3	35.44	36.31	48
49	1.31	3. 3	4.35	6. 6	7.38	9.10	10.42	12.15	13.48	15.21	16.54	18.29	20. 3	21.38	23.14	24.51	26.28	28. 6	29.45	31.25	33. 7	34.49	36.33	37.22	49
50	1.33	3. 7	4.40	6.14	7.48	9.22	10.56	12.30	14. 5	15.40	17.16	18.52	20.29	22. 7	23.45	25.24	27. 3	28.44	30.26	32. 9	33.53	35.39	37.26	38.17	50
51	1.35	3.11	4.46	6.22	7.58	9.34	11.10	12.47	14.24	16. 1	17.39	19.17	20.57	22.36	24.17	25.59	27.41	29.25	31. 9	32.55	34.43	36.32	38.23	39.15	51
52	1.37	3.15	4.53	6.30	8. 8	9.47	11.25	13. 4	14.43	16.23	18. 3	19.44	21.26	23. 8	24.52	26.36	28.21	30. 8	31.56	33.45	35.36	37.29	39.24	40.18	52
53	1.40	3.19	4.59	6.39	8.20	10. 0	11.41	13.22	15. 4	16.46	18.29	20.13	21.57	23.42	25.28	27.16	29. 4	30.54	32.45	34.38	36.33	38.30	40.29	41.26	53
54	1.42	3.24	5. 7	6.49	8.32	10.15	11.58	13.42	15.26	17.11	18.57	20.43	22.30	24.18	26. 7	27.58	29.50	31.43	33.38	35.35	37.34	39.36	41.40	42.39	54
55	1.45	3.29	5.14	6.59	8.44	10.30	12.16	14. 3	15.50	17.37	19.26	21.15	23. 5	24.57	26.49	28.43	30.39	32.36	34.35	36.36	38.40	40.47	42.56	43.58	55
56	1.47	3.35	5.22	7.10	8.58	10.46	12.35	14.25	16.15	18. 5	19.57	21.50	23.43	25.38	27.34	29.32	31.31	33.33	35.36	37.42	39.51	42. 4	44.20	45.24	56
57	1.50	3.40	5.31	7.22	9.13	11. 4	12.56	14.48	16.42	18.36	20.30	22.26	24.24	26.22	28.22	30.24	32.28	34.34	36.43	38.54	41. 9	43.27	45.50	46.59	57
58	1.53	3.47	5.40	7.34	9.28	11.23	13.18	15.14	17.10	19. 8	21. 6	23. 6	25. 7	27.10	29.14	31.21	33.29	35.40	37.54	40.12	42.33	44.59	47.30	48.43	58
59	1.57	3.53	5.50	7.47	9.45	11.43	13.41	15.41	17.41	19.42	21.45	23.49	25.54	28. 1	30.10	32.21	34.35	36.52	39.12	41.37	44. 6	46.40	49.21	50.38	59
60	2. 0	4. 0	6. 0	8. 1	10. 2	12. 4	14. 6	16.10	18.14	20.19	22.26	24.34	26.44	28.56	31.10	33.27	35.47	38 10	40.38	43.10	45.47	48.31	51.24	52.47	60
61	2. 4	4. 8	6.12	8.16	10.21	12.27	14.34	16.41	18.49	20.59	23.11	25.24	27.39	29.56	32.16	34.39	37. 5	39.36	42.11	44.52	47.40	50.36	53.42	55.13	61
62	2. 8	4.16	6.24	8.33	10.42	12.52	15. 3	17.15	19.28	21.42	23.59	26.17	28.38	31. 1	33.27	35.57	38.31	41.10	43.54	46.46	49.46	52.56	56.20	58. 1	62
63	2.12	4.25	6.37	8.50	11. 4	13.19	15.34	17.51	20. 9	22.29	24.51	27.15	29.42	32.12	34.45	37.23	40. 5	42.54	45.49	48.53	52. 8	55.36	59.23	61.18	63
64	2.17	4.34	6.51	9. 9	11.28	13.48	16. 8	18.31	20.54	23.20	25.48	28.19	30.52	33.30	36.11	38.58	41.50	44.49	47.58	51.17	54.50	58.43	63. 2	65.17	64
65	2.22	4.44	7. 7	9.30	11.54	14.19	16.46	19.14	21.44	24.16	26.50	29.28	32.10	34.55	37.46	40.43	43.46	46.59	50.23	54. 2	57.59	62.25	67.36	70.26	65
66	2.28	4.55	7.24	9.53	12.22	14.54	17.26	20. 1	22.37	25.16	27.59	30.45	33.35	36.30	39.31	42.40	45.57	49.27	53.10	57.14	61.46	67. 4	73.52	78.15	66

Digitized by Google

TABLE VIII.

Right Ascensions and Declinations of some of the principal Fixed Stars, adapted to the beginning of the Year 1830, with their Annual Variations.

Names and Situations of the STARS.	Characters.	Magnitudes.	Right Ascension.	Annual Variat. R. A. Add after 1830.	Declination.	Annual Variation.
			H. M. S.	″	° ′	″
Cassiopeiæ	β	2.3	0. 0. 9	3.12	58.13 N.	+ 20.0
Pegasi ... *Algenib*	γ	2	0. 4.30	3.08	14.14 N.	+ 20.0
Phœnicis	α	2.3	0.17.51	2.97	43.14 S.	− 20.0
Andromedæ	δ	3	0.30.15	3.17	29.56 N.	+ 19.9
Cassiopeiæ ... *Schedir*	α	3	0.30.55	3.33	55.36 N.	+ 19.9
Ceti ... *Deneb Kaitos*	β	2.3	0.35.03	3.00	18.55 S.	− 19.8
Cassiopeiæ	γ	3	0.46.31	3.53	59.48 N.	+ 19.6
Polar Star, tail of the Little Bear	α	2.3	0.59.31	15.52	88.24 N.	+ 19.4
Ceti	η	3.4	1.00.02	3.00	11.05 S.	− 19.4
Andromedæ ... *Mirach*	β	2	1.00.14	3.31	34.43 N.	+ 19.4
Cassiopeiæ	δ	3	1.14.46	3.83	59.21 N.	+ 19.0
Ceti	θ¹	3	1.15.32	3.00	9.04 S.	− 19.0
Eridani ... *Achernar*	α	1	1.31.22	2.24	58.06 S.	− 18.5
Cassiopeiæ	ε	3.4	1.42.15	4.19	62.50 N.	+ 18.1
Ceti ... *Baten Kaitos*	ζ	3	1.43.05	2.95	11.11 S.	− 18.1
Trianguli	α	3.4	1.43.25	3.39	28.45 N.	+ 18.0
Arietis	β	3	1.45.16	3.28	19.58 N.	+ 18.0
Andromedæ ... *Alamak*	γ	2	1.53.30	3.63	41.31 N.	+ 17.6
*ARIETIS	α	2	1.57.36	3.34	22.39 N.	+ 17.5
Ceti	o	2	2.10.46	3.02	3.45 S.	− 16.9
Ceti	γ	3	2.34.30	3.11	2.31 N.	+ 15.7
Arietis		3	2.40.00	3.50	26.33 N.	+ 15.4
Eridani	η	3	2.48.07	2.92	9.35 S.	− 14.9
Ceti ... *Menkar*	α	2	2.53.24	3.12	3.25 N.	+ 14.6
Persei ... *Algol*	β	2.3	2.57.08	3.86	40.18 N.	+ 14.3
Eridani		3.4	3.04.51	2.56	29.40 S.	− 14.7
Persei ... *Algenib*	α	2	3.12.14	4.22	49.15 N.	+ 13.4
Persei	δ	3.4	3.30.51	4.22	47.14 N.	+ 12.1
Eridani	δ	3.4	3.35.07	2.87	10.21 S.	− 11.2
Tauri ... *Pleiadum*	η	3	3.37.24	3.54	23.34 N.	+ 11.7
Persei	ζ	3.4	3.43.28	3.74	31.22 N.	+ 11.2
Tauri	γ	3.4	4.10.08	3.39	15.13 N.	+ 9.2
Tauri ... *ALDEBARAN	α	1	4.26.11	3.42	16.10 N.	+ 8.0
Eridani	υ²	3	4.28.57	2.33	30.55 S.	− 7.8
Eridani	β	3	4.59.30	2.95	5.19 S.	− 5.2
Aurigæ. Capellæ ... *Alajoth*	α	1	5.04.09	4.40	45.49 N.	+ 4.8
Orionis ... *Rigel*	β	1	5.06.22	2.88	8.24 S.	− 4.6
Tauri	β	2	5.15.33	3.78	28.27 N.	+ 3.9
Orionis ... *Bellatrix*	γ	2	5.16.01	3.21	6.11 N.	+ 3.8
Orionis	δ	2	5.23.20	3.06	0.26 S.	− 3.2
Leporis	α	3.4	5.25.14	2.64	17.57 S.	− 3.0
Orionis	ι	3.4	5.27.07	2.93	6.02 S.	− 2.9
Orionis	ε	2	5.27.35	3.04	1.19 S.	− 2.8
Orionis	ζ	2	5.32.11	3.02	2.02 S.	− 2.4
Columbæ	α	2	5.33.30	2.17	34.10 S.	− 2.3
Orionis	κ	3	5.39.42	2.84	9.44 S.	− 1.8
Columbæ	β	3	5.44.58	2.11	35.51 S.	− 1.3
Aurigæ	δ	3.4	5.45.32	4.92	54.16 N.	+ 1.3
Orionis ... *Betergueze*	α	1	5.45.58	3.24	7.22 N.	+ 1.2
Aurigæ	β	2	5.47.04	4.40	44.55 N.	+ 1.1

Digitized by Google

TABLE VIII.

Right Ascensions and Declinations of some of the principal Fixed Stars, adapted to the beginning of the Year 1830, with their Annual Variations.

Names and Situations of the STARS.	Characters.	Magnitudes.	Right Ascension.	Annual Variat. R. A. Add after 1830.	Declination.	Annual Variation.
			H. M. S.	″	° ′	″
Geminorum	μ	3	6.12.41	3.62	22.36 N.	− 1.1
Canis Majoris	ζ	3	6.13.47	2.30	30.00 S.	+ 1.2
Canis Majoris	β	2.3	6.15.13	2.64	17.53 S.	+ 1.3
Argus ... *Canopus*	α	1	6.20.11	1.33	52.36 S.	+ 1.8
Geminorum	γ	3	6.27.53	3.46	16.32 N.	− 2.4
Geminorum	ε	3	6.33.28	3.69	25.17 N.	− 2.9
Canis Majoris ... *Sirius*	α	1	6.37.39	2.64	16.29 S.	+ 4.4
Canis Majoris	ε	2.3	6.51.57	2.35	28.45 S.	+ 4.5
Canis Majoris	σ	3.4	6.54.57	2.39	27.42 S.	+ 4.8
Canis Majoris	δ	3.4	7.01.29	2.44	26.08 S.	+ 5.3
Geminorum	δ	3.4	7.09.58	3.59	22.17 N.	− 6.0
Canis Majoris	η	3	7.17.22	2.37	28.59 S.	+ 6.6
Canis Minoris	β	3	7.17.56	3.26	8.38 N.	− 6.7
Geminorum ... *Castor*	α	1.2	7.23.44	3.86	32.15 N.	− 7.2
Canis Minoris ... *Procyon*	α	1.2	7.30.24	3.14	5.39 N.	− 8.7
Geminorum ... *POLLUX	β	2	7.34.54	3.68	28.26 N.	− 8.1
Argus	ζ	2	7.57.37	2.11	39.32 S.	+ 9.8
Argus	ι	3.4	8.00.18	2.56	23.49 S.	+ 10.0
Argus	γ^2	2	8.04.18	1.85	46.50 S.	+ 10.3
Argus	δ	2.3	8.40.01	1.66	54.05 S.	+ 12.9
Ursæ Majoris	ι^1	3.4	8.47.32	4.13	48.42 N.	− 13.4
Argus	β	2.3	9.11.19	0.73	69.01 S.	+ 14.9
Hydræ ... *Alphard*	α	2	9.19.14	2.95	7.56 S.	+ 15.3
Ursæ Majoris	θ	3	9.21.27	4.06	52.27 N.	− 16.0
Leonis	ε	3	9.36.11	3.43	24.33 N.	− 16.2
Leonis	μ	3	9.43.05	3.45	26.48 N.	− 16.6
Leonis	η	3.4	9.58.03	3.28	17.35 N.	− 17.3
Leonis ... *REGULUS	α	1	9.59.19	3.22	12.48 N.	− 17.3
Ursæ Majoris	λ	3.4	10.06.49	3.68	43.46 N.	− 17.6
Leonis	γ	2	10.10.35	3.30	20.42 N.	− 17.8
Ursæ Majoris	μ	3	10.12.10	3.62	42.21 N.	− 17.9
Ursæ Majoris	β	2	10.51.32	3.68	57.17 N.	− 19.2
Ursæ Majoris ... *Dubhe*	α	1.2	10.53.10	3.81	62.40 N.	− 19.2
Ursæ Majoris	ψ	3.4	11.00.05	3.42	45.25 N.	− 19.4
Leonis	δ	3	11.05.03	3.19	21.27 N.	− 19.5
Leonis	θ	3	11.05.19	3.16	16.21 N.	− 19.5
Hydræ and Crateris	δ	3.4	11.10.51	3.00	13.52 S.	+ 19.6
Draconis	λ	3.4	11.21.13	3.70	70.16 N.	− 19.8
Leonis ... *Denebola*	β	2.3	11.40.23	3.06	15.31 N.	− 20.0
Virginis	β	3.4	11.41.51	3.12	2.43 N.	− 20.0
Ursæ Majoris	γ	2	11.44.51	3.19	54.38 N.	− 20.0
Ursæ Majoris	δ	3	12.06.58	3.00	57.59 N.	− 20.0
Corvi	γ	3	12.07.05	3.08	16.36 S.	+ 20.0
Virginis	η	3.4	12.11.13	3.07	0.17 N.	− 20.0
Crucis	α	1	12.17.11	3.26	62.09 S.	+ 20.0
Corvi	δ	3	12.21.05	3.10	15.34 S.	+ 20.0
Crucis	γ	2	12.21.48	3.26	56.09 S.	+ 20.0
Corvi ... *Algorab*	β	2.3	12.25.28	3.13	22.27 S.	+ 19.9
Draconis	κ	3.4	12.26.11	2.60	70.44 N.	− 19.9
Crucis	β	2	12.37.52	3.43	58.45 S.	+ 19.8

Digitized by Google

TABLE VIII.

Right Ascensions and Declinations of some of the principal Fixed Stars, adapted to the beginning of the Year 1830, with their Annual Variations.

Names and Situations of the STARS.	Characters.	Magnitudes.	Right Ascension.	Annual Variat. R. A. Add after 1830.	Declination.	Annual Variation.
			H. M. S.	″	° ′	″
Ursæ Majoris .... *Alioth*	ε	2.3	12.46.32	2.66	56.53 N.	— 19.6
Canum Venatis .... *Cor Caroli*		2.3	12.48.04	2.84	39.14 N.	— 19.6
Centauri	ι	3	13.11.04	3.36	35.49 S.	+ 19.1
Virginis .... *Spica	α	1	13.16.15	3.15	10.16 S.	+ 18.9
Ursæ Majoris	ζ	2.3	13.17.04	2.42	55.49 N.	— 18.9
Ursæ Majoris .... *Benetnasch*	η	2	13.40.50	1.35	50.10 N.	— 18.1
Bootis	η	3	13.46.36	2.86	19.15 N.	— 17.9
Centauri	β	2	13.51.55	4.13	59.33 S.	+ 17.7
Centauri	θ	2	13.56.42	3.49	35.32 S.	+ 17.5
Draconis	α	3	13.59.47	1.63	65.11 N.	— 17.4
Bootis .... *Arcturus*	α	1	14.07.55	2.73	20.04 N.	— 19.0
Centauri	α²	1	14.28.14	4.47	60.08 S.	+ 16.0
Bootis .... *Mirac*	ε	3	14.37.34	2.62	27.48 N.	— 15.5
Libræ .... *Zubeneschamah*	α²	2.3	14.41.29	3.31	15.20 S.	+ 15.3
Libræ .... *Zubenelgubi*		3.4	14.54.09	3.49	24.36 S.	+ 14.5
Bootis	β	3	14.55.33	2.26	41.04 N.	— 14.4
Libræ .... *Zubenelgemubi*	β	2.3	15.07.52	3.22	8.45 S.	+ 13.7
Draconis	ι	3	15.2[illegible].09	1.32	59.34 N.	— 12.8
Serpentis	δ	3	15.26.41	2.86	11.07 N.	— 12.4
Coronæ Borealis .... *Gemma*	α	2	15.27.30	2.53	27.18 N.	— 12.4
Serpentis	α	2	15.35.54	2.94	6.58 N.	— 11.8
Serpentis	ε	3	15.42.21	2.97	5.00 N.	— 11.3
Serpentis	γ	3	15.48.36	2.74	16.13 N.	— 12.2
Scorpii	δ	3	15.50.18	3.53	22.08 S.	+ 10.7
Scorpii	β¹	2	15.55.34	3.47	19.20 S.	+ 10.4
Scorpii	β²	5.6	15.55.34	3.47	19.20 S.	+ 10.4
Ophiuchi	δ	3	16.05.27	3.14	3.15 S.	+ 9.6
Ophiuchi	ε	3	16.09.20	3.16	4.16 S.	+ 9.3
Herculis	γ	3.4	16.14.25	2.64	19.33 N.	— 8.9
Scorpii .... *Antares	α	1	16.19.00	3.66	26.03 S.	+ 8.6
Draconis	η	3	16.21.42	0.79	61.54 N.	— 8.3
Herculis	β	2.3	16.22.55	2.58	21.52 N.	— 8.2
Ophiuchi	ζ	3.4	16.27.48	3.29	10.13 S.	+ 7.9
Herculis	ζ	3	16.34.53	2.25	31.55 N.	— 7.3
Herculis	η	3	16.37.04	2.05	39.15 N.	- 7.1
Scorpii	ε	3	16.39.10	3.87	33.59 S.	+ 5.9
Herculis	ε	3	16.53.47	2.29	31.11 N.	- 5.7
Ophiuchi	η	2.3	17.00.38	3.43	15.30 S.	+ 5.1
Herculis	α	2	17.06.54	2.73	14.35 N.	- 4.6
Draconis	ζ	3	17.08.19	0.15	65.55 N.	- 4.5
Scorpii .... *Lesath*	λ	3	17.22.05	4.06	36.59 S.	+ 3.3
Draconis	β	2	17.26.36	1.35	52.26 N.	— 2.9
Ophiuchi	α	2	17.27.03	2.77	12.41 N.	- 2.9
Ophiuchi	β	3	17.35.05	2.96	4.39 N.	2.2
Draconis .... *Etanin*	γ	2	17.52.40	1.39	51.31 N.	— 0.6
Sagittarii	ε	2.3	18.12.53	3.98	34.27 S.	- 1.1
Lyræ .... *Wega*	α	1	18.31.11	2.01	38.38 N.	+ 2.7
Lyræ	β	3	18.43.48	2.21	33.10 N.	+ 3.8
Sagittarii	σ	3	18.44.43	3.72	26.30 S.	3.9
Lyræ	γ	3	18.52.35	2.24	32.28 N.	+ 4.6

Digitized by Google

TABLE VIII.

Right Ascensions and Declinations of some of the principal Fixed Stars, adapted to the beginning of the Year 1830, with their Annual Variations.

Names and Situations of the STARS.	Characters.	Magnitudes.	Right Ascension.	Annual Variat. R. A. Add after 1830.	Declination	Annual Variation.
			H. M. S.	″	° ′	″
Aquilæ	λ	3	18.57.14	3.18	5.08 S.	− 5.0
Aquilæ	ζ	3	18.57.36	2.75	13.37 N.	+ 5.0
Draconis	δ	3	19.12.30	0.02	67.22 N.	+ 6.2
Cygni	β^1	3	19.23.52	2.42	27.36 N.	+ 7.2
Aquilæ	γ	3	19.38.11	2.85	10.12 N.	+ 8.3
Aquilæ .... *ALTAIR	α	1	19.42.29	2.92	8.26 N.	+ 8.7
Capricorni	α^2	3	20.08.37	3.33	13.04 S.	− 10.7
Pavonis	α	2	20.12.09	4.81	57.16 S.	− 10.9
Cygni	γ	3	20.16.08	2.15	39.43 N.	+ 11.2
Delphini	α	3.4	20.31.45	2.78	15.19 N.	+ 12.3
Delphini	δ	3.4	20.35.31	2.80	14.28 N.	+ 12.6
Cygni .... *Deneb*	α	1	20.35.38	2.04	44.41 N.	+ 12.6
Cygni	ε	3	20.39.20	2.39	33.20 N.	+ 12.8
Cephei	η	3.4	20.41.49	1.22	61.11 N.	+ 13.8
Cygni	ζ	3	21.05.42	2.55	29.32 N.	+ 14.5
Cephei .... *Alderamin*	α	3	21.14.31	1.42	61.52 N.	+ 15.0
Aquarii	β	3	21.22.36	3.16	6.19 S.	− 15.5
Cephei	β	3	21.26.26	0.81	69.49 N.	+ 15.7
Pegasi	ε	2.3	21.35.50	2.94	9.06 N.	+ 16.2
Capricorni	δ	3.4	21.37.39	3.30	16.54 S.	− 16.3
Aquarii	α	3	21.57.03	3.08	1.09 S.	− 17.2
Gruis	*α	2	21.57.29	3.82	47.47 S.	− 17.2
Pegasi	ζ	3	22.32.59	2.98	9.57 N.	+ 18.6
Pegasi	η	3	22.35.03	2.80	29.20 N.	+ 18.7
Aquarii	δ	3	22.45.37	3.20	16.43 S.	− 19.0
Piscis Australis .... *FOMALHAUT	α	1	22.48.14	3.31	30.31 S.	− 19.1
Pegasi	β	2	22.55.33	2.88	27.10 N.	+ 19.3
Pegasi .... *MARKAB	α	2	22.56.18	2.98	14.18 N.	+ 19.3
Cephei	γ	3	23.32.26	2.39	76.41 N.	+ 19.9
Andromedæ	α	2	23.59.37	3.07	28.09 N.	+ 20.0

NOTE.—If the places of these stars are wanted for any time before the beginning of the year 1830, multiply the annual variation, in right ascension, by the number of years before 1830, and subtract the product from the right ascension standing in the table; but the product of the annual variation in declination by the number of years before 1830 must be added to, or subtracted from the declination, according as the sign — or + is marked in the Table; but for any years after 1830, the annual variation in right ascension, multiplied by the number of years after 1830, must be added to the right ascension in the Table, and the annual variation in declination, multiplied by the number of years after 1830, must be either added to, or subtracted from the declination, according to the signs in the Table. The Annual Variation is set down for seconds and decimals of a second. An asterisk is prefixed to the stars whose distances from the moon are given in the Nautical Almanac. When very great accuracy is required, the corrections found in Tables XLII. and XLIII., for aberration and nutation, are to be applied to the numbers deduced from Table VIII.; but these corrections are generally not of much importance in nautical calculations. The corrected values are, however, given in the Nautical Almanac for 100 of the bright stars of this catalogue for every ten days in the year, and these values are always to be preferred.

Digitized by Google

TABLE IX.

A TABLE showing the Time of the Sun's Setting, when the Latitude and Declination are of the same Name, and the Time of its Rising, when the Latitude and Declination are of different Names.

DECLINATION.

Lat.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	23° 28′	Lat.
	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H. M.	
1°	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.02	6.02	6.02	6.02	1°
2	6.00	6.00	6.00	6.00	6.01	6.01	6.01	6.01	6.01	6.01	6.01	6.02	6.02	6.02	6.02	6.02	6.02	6.02	6.03	6.03	6.03	6.03	6.03	6.03	6.03	2
3	6.00	6.00	6.00	6.01	6.01	6.01	6.01	6.01	6.02	6.02	6.02	6.02	6.03	6.03	6.03	6.03	6.03	6.04	6.04	6.04	6.04	6.05	6.05	6.05	6.05	3
4	6.00	6.00	6.01	6.01	6.01	6.01	6.02	6.02	6.02	6.03	6.03	6.03	6.03	6.04	6.04	6.04	6.05	6.05	6.05	6.06	6.06	6.06	6.06	6.07	6.07	4
5	6.00	6.00	6.01	6.01	6.01	6.02	6.02	6.02	6.03	6.03	6.04	6.04	6.04	6.05	6.05	6.05	6.06	6.06	6.07	6.07	6.07	6.08	6.08	6.09	6.09	5
6	6.00	6.00	6.01	6.01	6.02	6.02	6.03	6.03	6.03	6.04	6.04	6.05	6.05	6.06	6.06	6.06	6.07	6.07	6.08	6.08	6.09	6.09	6.10	6.10	6.10	6
7	6.00	6.00	6.01	6.01	6.02	6.02	6.03	6.03	6.04	6.04	6.05	6.05	6.06	6.06	6.07	6.08	6.08	6.09	6.09	6.10	6.10	6.11	6.11	6.12	6.12	7
8	6.00	6.01	6.01	6.02	6.02	6.03	6.03	6.04	6.05	6.05	6.06	6.06	6.07	6.07	6.08	6.09	6.09	6.10	6.10	6.11	6.12	6.12	6.13	6.14	6.14	8
9	6.00	6.01	6.01	6.02	6.03	6.03	6.04	6.04	6.05	6.06	6.06	6.07	6.08	6.08	6.09	6.10	6.10	6.11	6.12	6.13	6.13	6.14	6.15	6.15	6.16	9
10	6.00	6.01	6.01	6.02	6.03	6.04	6.04	6.05	6.06	6.06	6.07	6.08	6.09	6.09	6.10	6.11	6.12	6.12	6.13	6.14	6.15	6.16	6.16	6.17	6.18	10
11	6.00	6.01	6.02	6.02	6.03	6.04	6.05	6.05	6.06	6.07	6.08	6.09	6.09	6.10	6.11	6.12	6.13	6.14	6.14	6.15	6.16	6.17	6.18	6.19	6.19	11
12	6.00	6.01	6.02	6.03	6.03	6.04	6.05	6.06	6.07	6.08	6.09	6.09	6.10	6.11	6.12	6.13	6.14	6.15	6.16	6.17	6.18	6.19	6.20	6.21	6.21	12
13	6.00	6.01	6.02	6.03	6.04	6.05	6.06	6.06	6.07	6.08	6.09	6.10	6.11	6.12	6.13	6.14	6.15	6.16	6.17	6.18	6.19	6.20	6.21	6.22	6.23	13
14	6.00	6.01	6.02	6.03	6.04	6.05	6.06	6.07	6.08	6.09	6.10	6.11	6.12	6.13	6.14	6.15	6.16	6.17	6.19	6.20	6.21	6.22	6.23	6.24	6.25	14
15	6.00	6.01	6.02	6.03	6.04	6.05	6.06	6.08	6.09	6.10	6.11	6.12	6.13	6.14	6.15	6.16	6.18	6.19	6.20	6.21	6.22	6.24	6.25	6.26	6.27	15
16	6.00	6.01	6.02	6.03	6.05	6.06	6.07	6.08	6.09	6.10	6.12	6.13	6.14	6.15	6.16	6.18	6.19	6.20	6.21	6.23	6.24	6.25	6.27	6.28	6.29	16
17	6.00	6.01	6.02	6.04	6.05	6.06	6.07	6.09	6.10	6.11	6.12	6.14	6.15	6.16	6.17	6.19	6.20	6.21	6.23	6.24	6.26	6.27	6.28	6.30	6.31	17
18	6.00	6.01	6.03	6.04	6.05	6.07	6.08	6.09	6.10	6.12	6.13	6.14	6.16	6.17	6.19	6.20	6.21	6.23	6.24	6.26	6.27	6.29	6.30	6.32	6.32	18
19	6.00	6.01	6.03	6.04	6.06	6.07	6.08	6.10	6.11	6.13	6.14	6.15	6.17	6.18	6.20	6.21	6.23	6.24	6.26	6.27	6.29	6.30	6.32	6.34	6.34	19
20	6.00	6.01	6.03	6.04	6.06	6.07	6.09	6.10	6.12	6.13	6.15	6.16	6.18	6.19	6.21	6.22	6.24	6.26	6.27	6.29	6.30	6.32	6.34	6.36	6.36	20
21	6.00	6.02	6.03	6.05	6.06	6.08	6.09	6.11	6.12	6.14	6.16	6.17	6.19	6.20	6.22	6.24	6.25	6.27	6.29	6.30	6.32	6.34	6.36	6.38	6.38	21
22	6.00	6.02	6.03	6.05	6.06	6.08	6.10	6.11	6.13	6.15	6.16	6.18	6.20	6.21	6.23	6.25	6.27	6.28	6.30	6.32	6.34	6.36	6.38	6.39	6.40	22
23	6.00	6.02	6.03	6.05	6.07	6.09	6.10	6.12	6.14	6.15	6.17	6.19	6.21	6.22	6.24	6.26	6.28	6.30	6.32	6.34	6.36	6.38	6.39	6.42	6.42	23
24	6.00	6.02	6.04	6.05	6.07	6.09	6.11	6.13	6.14	6.16	6.18	6.20	6.22	6.24	6.25	6.27	6.29	6.31	6.33	6.35	6.37	6.39	6.41	6.44	6.45	24
25	6.00	6.02	6.04	6.06	6.07	6.09	6.11	6.13	6.15	6.17	6.19	6.21	6.23	6.25	6.27	6.29	6.31	6.33	6.35	6.37	6.39	6.41	6.43	6.46	6.47	25
26	6.00	6.02	6.04	6.06	6.08	6.10	6.12	6.14	6.16	6.18	6.20	6.22	6.24	6.26	6.28	6.30	6.32	6.34	6.36	6.39	6.41	6.43	6.45	6.48	6.49	26
27	6.00	6.02	6.04	6.06	6.08	6.10	6.12	6.14	6.16	6.19	6.21	6.23	6.25	6.27	6.29	6.31	6.34	6.36	6.38	6.40	6.43	6.45	6.48	6.50	6.51	27
28	6.00	6.02	6.04	6.06	6.09	6.11	6.13	6.15	6.17	6.19	6.22	6.24	6.26	6.28	6.30	6.33	6.35	6.37	6.40	6.42	6.45	6.47	6.50	6.52	6.53	28
29	6.00	6.02	6.04	6.07	6.09	6.11	6.13	6.16	6.18	6.20	6.22	6.25	6.27	6.29	6.32	6.34	6.37	6.39	6.42	6.44	6.47	6.49	6.52	6.54	6.56	29
30	6.00	6.02	6.05	6.07	6.09	6.12	6.14	6.16	6.19	6.21	6.23	6.26	6.28	6.31	6.33	6.36	6.38	6.41	6.43	6.46	6.49	6.51	6.54	6.57	6.58	30

Digitized by Google

A TABLE showing the Time of the Sun's Setting, when the Latitude and Declination are of the same Name, and the Time of its Rising, when the Latitude and Declination are of different Names.

DECLINATION.

Lat.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	23° 28'	Lat.
	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H. M.	
31°	6.00	6.02	6.05	6.07	6.10	6.12	6.14	6.17	6.19	6.22	6.24	6.27	6.29	6.32	6.34	6.37	6.40	6.42	6.45	6.48	6.51	6.53	6.56	6.59	7.00	31°
32	6.00	6.02	6.05	6.08	6.10	6.13	6.15	6.18	6.20	6.23	6.25	6.28	6.31	6.33	6.36	6.39	6.41	6.44	6.47	6.50	6.53	6.56	6.58	7.02	7.03	32
33	6.00	6.03	6.05	6.08	6.10	6.13	6.16	6.18	6.21	6.24	6.26	6.29	6.32	6.34	6.37	6.40	6.43	6.46	6.49	6.52	6.55	6.58	7.01	7.04	7.05	33
34	6.00	6.03	6.05	6.08	6.11	6.14	6.16	6.19	6.22	6.25	6.27	6.30	6.33	6.36	6.39	6.42	6.45	6.48	6.51	6.54	6.57	7.00	7.03	7.07	7.08	34
35	6.00	6.03	6.06	6.08	6.11	6.14	6.17	6.20	6.23	6.25	6.28	6.31	6.34	6.37	6.40	6.43	6.46	6.49	6.53	6.56	6.59	7.02	7.06	7.09	7.11	35
36	6.00	6.03	6.06	6.09	6.12	6.15	6.18	6.20	6.23	6.26	6.29	6.32	6.36	6.39	6.42	6.45	6.48	6.51	6.55	6.58	7.01	7.05	7.08	7.12	7.14	36
37	6.00	6.03	6.06	6.09	6.12	6.15	6.18	6.21	6.24	6.27	6.31	6.34	6.37	6.40	6.43	6.47	6.50	6.53	6.57	7.00	7.04	7.07	7.11	7.15	7.16	37
38	6.00	6.03	6.06	6.09	6.13	6.16	6.19	6.22	6.25	6.28	6.32	6.35	6.38	6.42	6.45	6.48	6.52	6.55	6.59	7.02	7.06	7.10	7.14	7.17	7.19	38
39	6.00	6.03	6.06	6.10	6.13	6.16	6.20	6.23	6.26	6.29	6.33	6.36	6.40	6.43	6.47	6.50	6.54	6.57	7.01	7.05	7.09	7.12	7.16	7.20	7.22	39
40	6.00	6.03	6.07	6.10	6.13	6.17	6.20	6.24	6.27	6.31	6.34	6.38	6.41	6.45	6.48	6.52	6.56	6.59	7.03	7.07	7.11	7.15	7.19	7.23	7.25	40
41	6.00	6.03	6.07	6.10	6.14	6.17	6.21	6.25	6.28	6.32	6.35	6.39	6.43	6.46	6.50	6.54	6.58	7.02	7.06	7.10	7.14	7.18	7.22	7.27	7.29	41
42	6.00	6.04	6.07	6.11	6.14	6.18	6.22	6.25	6.29	6.33	6.37	6.40	6.44	6.48	6.52	6.56	7.00	7.04	7.08	7.12	7.17	7.21	7.25	7.30	7.32	42
43	6.00	6.04	6.07	6.11	6.15	6.19	6.22	6.26	6.30	6.34	6.38	6.42	6.46	6.50	6.54	6.58	7.02	7.06	7.11	7.15	7.19	7.24	7.29	7.33	7.36	43
44	6.00	6.04	6.08	6.12	6.15	6.19	6.23	6.27	6.31	6.35	6.39	6.43	6.47	6.52	6.56	7.00	7.04	7.09	7.13	7.18	7.22	7.27	7.32	7.37	7.39	44
45	6.00	6.04	6.08	6.12	6.16	6.20	6.24	6.28	6.32	6.36	6.41	6.45	6.49	6.53	6.58	7.02	7.07	7.11	7.16	7.21	7.25	7.30	7.35	7.40	7.43	45
46	6.00	6.04	6.08	6.12	6.17	6.21	6.25	6.29	6.33	6.38	6.42	6.46	6.51	6.55	7.00	7.04	7.09	7.14	7.19	7.24	7.29	7.34	7.39	7.44	7.47	46
47	6.00	6.04	6.09	6.13	6.17	6.22	6.26	6.30	6.35	6.39	6.44	6.48	6.53	6.57	7.02	7.07	7.12	7.17	7.22	7.27	7.32	7.37	7.43	7.48	7.51	47
48	6.00	6.04	6.09	6.13	6.18	6.22	6.27	6.31	6.36	6.41	6.45	6.50	6.55	6.59	7.04	7.09	7.14	7.19	7.25	7.30	7.35	7.41	7.47	7.53	7.55	48
49	6.00	6.05	6.09	6.14	6.18	6.23	6.28	6.32	6.37	6.42	6.47	6.52	6.57	7.02	7.07	7.12	7.17	7.22	7.28	7.33	7.39	7.45	7.51	7.57	8.00	49
50	6.00	6.05	6.10	6.14	6.19	6.24	6.29	6.34	6.39	6.44	6.49	6.54	6.59	7.04	7.09	7.14	7.20	7.25	7.31	7.37	7.43	7.49	7.55	8.02	8.05	50
51	6.00	6.05	6.10	6.15	6.20	6.25	6.30	6.35	6.40	6.45	6.50	6.56	7.01	7.06	7.12	7.17	7.23	7.29	7.35	7.41	7.47	7.53	8.00	8.06	8.10	51
52	6.00	6.05	6.10	6.15	6.21	6.26	6.31	6.36	6.41	6.47	6.52	6.58	7.03	7.09	7.14	7.20	7.26	7.32	7.38	7.45	7.51	7.58	8.05	8.12	8.15	52
53	6.00	6.05	6.11	6.16	6.21	6.27	6.32	6.38	6.43	6.49	6.54	7.00	7.06	7.11	7.17	7.23	7.29	7.36	7.42	7.49	7.56	8.02	8.10	8.17	8.21	53
54	6.00	6.06	6.11	6.17	6.22	6.28	6.33	6.39	6.45	6.50	6.56	7.02	7.08	7.14	7.20	7.27	7.33	7.40	7.46	7.53	8.00	8.08	8.15	8.23	8.27	54
55	6.00	6.06	6.11	6.17	6.23	6.29	6.35	6.40	6.46	6.52	6.58	7.04	7.11	7.17	7.23	7.30	7.37	7.44	7.51	7.58	8.05	8.13	8.21	8.29	8.33	55
56	6.00	6.06	6.12	6.18	6.24	6.30	6.36	6.42	6.48	6.54	7.01	7.07	7.13	7.20	7.27	7.34	7.41	7.48	7.55	8.03	8.11	8.19	8.27	8.36	8.40	56
57	6.00	6.06	6.12	6.19	6.25	6.31	6.37	6.44	6.50	6.56	7.03	7.10	7.16	7.23	7.30	7.37	7.45	7.52	8.00	8.08	8.16	8.25	8.34	8.43	8.48	57
58	6.00	6.06	6.13	6.19	6.26	6.32	6.39	6.45	6.52	6.59	7.06	7.12	7.20	7.27	7.34	7.42	7.49	7.57	8.05	8.14	8.22	8.32	8.41	8.51	8.56	58
59	6.00	6.07	6.13	6.20	6.27	6.33	6.40	6.47	6.54	7.01	7.08	7.15	7.23	7.30	7.38	7.46	7.54	8.02	8.11	8.20	8.29	8.39	8.49	9.00	9.05	59
60	6.00	6.07	6.14	6.21	6.28	6.35	6.42	6.49	6.56	7.04	7.11	7.19	7.26	7.34	7.42	7.51	7.59	8.08	8.17	8.26	8.36	8.47	8.58	9.09	9.15	60

Digitized by Google

TABLE X.

For finding the Distance of Terrestrial Objects at Sea, in Statute Miles.

Height in feet.	Distance. Mil. Dec.	Height in feet.	Distance. Mil. Dec.	Height in feet.	Distance. Mil. Dec.	Height in feet.	Distance. Mil. Dec.	Height in feet.	Distance. Mil. Dec.	Height in feet.	Distance. Mil. Dec.	Height in feet.	Distance. Mil. Dec.
1	1.32	26	6.75	55	9.81	210	19.17	460	28.37	920	40.13	3100	73.7
2	1.87	27	6.87	60	10.25	220	19.62	470	28.68	940	40.56	3200	74.8
3	2.29	28	7.00	65	10.67	230	20.06	480	28.98	960	40.99	3300	76.0
4	2.65	29	7.12	70	11.07	240	20.50	490	29.29	980	41.42	3400	77.1
5	2.96	30	7.25	75	11.46	250	20.92	500	29.58	1000	41.80	3500	78.3
6	3.24	31	7.37	80	11.83	260	21.33	520	30.17	1100	43.90	3600	79.4
7	3.50	32	7.48	85	12.20	270	21.74	540	30.74	1200	45.80	3700	80.5
8	3.74	33	7.60	90	12.55	280	22.14	560	31.31	1300	47.70	3800	81.6
9	3.97	34	7.71	95	12.89	290	22.53	580	31.86	1400	49.50	3900	82.6
10	4.18	35	7.83	100	13.23	300	22.91	600	32.41	1500	51.20	4000	83.7
11	4.39	36	7.94	105	13.56	310	23.29	620	32.94	1600	52.90	4100	84.7
12	4.58	37	8.05	110	13.88	320	23.67	640	33.47	1700	54.50	4200	85.7
13	4.77	38	8.16	115	14.19	330	24.03	660	33.99	1800	56.10	4300	86.8
14	4.95	39	8.26	120	14.49	340	24.39	680	34.50	1900	57.70	4400	87.8
15	5.12	40	8.37	125	14.79	350	24.75	700	35.00	2000	59.20	4500	88.7
16	5.29	41	8.47	130	15.08	360	25.10	720	35.50	2100	60.60	4600	89.7
17	5.45	42	8.57	135	15.37	370	25.45	740	35.99	2200	62.10	4700	90.7
18	5.61	43	8.68	140	15.65	380	25.79	760	36.47	2300	63.40	4800	91.7
19	5.77	44	8.78	145	15.93	390	26.13	780	36.95	2400	64.80	4900	92.6
20	5.92	45	8.87	150	16.20	400	26.46	800	37.42	2500	66.10	5000	93.5
21	6.06	46	8.97	160	16.73	410	26.79	820	37.88	2600	67.50	1 mile	96.1
22	6.21	47	9.07	170	17.25	420	27.11	840	38.34	2700	68.70		
23	6.34	48	9.17	180	17.75	430	27.43	860	38.80	2800	70.00		
24	6.48	49	9.26	190	18.24	440	27.75	880	39.25	2900	71.20		
25	6.61	50	9.35	200	18.71	450	28.06	900	39.69	3000	72.50		

TABLE X. A.

Parallax in Altitude of a Planet.

Horizontal Parallax of a Planet.

Alt. D.	1	′ 2	′ 3	″ 4	″ 5	″ 6	″ 7	″ 8	″ 9	″ 10	″ 11	″ 12	″ 13	″ 14	″ 15	″ 16	″ 17	″ 18	″ 19	″ 20	″ 21	″ 22	″ 23	″ 24	″ 25	″ 26	″ 27	″ 28	″ 30	″ 35	Alt. D.
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30	35	0
10	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30	35	10
20	1	2	3	4	5	6	7	8	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	23	24	25	26	28	33	20
30	1	2	3	3	4	5	6	7	8	9	10	10	11	12	13	14	15	16	16	17	18	19	20	21	22	23	23	24	26	30	30
35	1	2	2	3	4	5	6	7	7	8	9	10	11	11	12	13	14	15	16	16	17	18	19	20	20	21	22	23	25	29	35
40	1	2	2	3	4	5	5	6	7	8	8	9	10	11	11	12	13	14	15	15	16	17	18	18	19	20	21	21	23	27	40
43	1	1	2	3	4	4	5	6	7	7	8	9	10	10	11	12	12	13	14	15	15	16	17	18	18	19	20	20	22	26	43
46	1	1	2	3	3	4	5	6	6	7	8	8	9	10	10	11	12	13	13	14	15	15	16	17	17	18	19	19	21	24	46
49	1	1	2	3	3	4	5	5	6	7	7	8	9	9	10	10	11	12	12	13	14	14	15	16	16	17	18	18	20	23	49
52	1	1	2	2	3	4	4	5	6	6	7	7	8	9	9	10	10	11	12	12	13	14	14	15	15	16	17	17	18	22	52
55	1	1	2	2	3	3	4	5	5	6	6	7	7	8	9	9	10	10	11	11	12	13	13	14	14	15	15	16	17	20	55
58	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	10	10	11	11	12	12	13	13	14	14	15	16	19	58
61	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	15	17	61
64	0	1	1	2	2	3	3	4	4	4	5	5	6	6	7	7	7	8	8	9	9	10	10	11	11	11	12	12	13	15	64
67	0	1	1	2	2	2	3	3	4	4	4	5	5	5	6	6	7	7	7	8	8	9	9	9	10	10	11	11	12	14	67
70	0	1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	8	8	8	9	9	9	10	10	12	70
72	0	1	1	1	2	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	6	7	7	7	8	8	8	9	9	11	72
74	0	1	1	1	1	2	2	2	2	3	3	3	4	4	4	4	5	5	5	6	6	6	6	7	7	7	7	8	8	10	74
76	0	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6	6	7	7	7	8	76
78	0	0	1	1	1	1	1	2	2	2	2	2	3	3	3	3	4	4	4	4	4	5	5	5	5	5	6	6	6	7	78
80	0	0	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	4	4	4	4	4	5	5	5	5	6	80
82	0	0	0	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	4	4	4	4	5	82
84	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	4	84
86	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	86
88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	88
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90

Digitized by Google

TABLE XI.

Seek the nearest number to the reduced time in the top column, and the difference of parallax, proportional logarithm, or semi-diameter for 12 hours in the side column; under the former, and opposite the latter, is the correction to be applied to the number, marked first in the Nautical Almanac, additive if increasing, subtractive if decreasing.

Reduced Time.

Variation in 12 hours.	h 0½ h 12½	h 1 h 13	h 1½ h 13½	h 2 h 14	h 2½ h 14½	h 3 h 15	h 3½ h 15½	h 4 h 16	h 4½ h 16½	h 5 h 17	h 5½ h 17½	h 6 h 18	h 6½ h 18½	h 7 h 19	h 7½ h 19½	h 8 h 20	h 8½ h 20½	h 9 h 21	h 9½ h 21½	h 10 h 22	h 10½ h 22½	h 11 h 23	h 11½ h 23½	h 12 h 24
1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
2	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
3	0	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3
4	0	0	0	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	4	4	4
5	0	0	1	1	1	1	1	2	2	2	2	2	3	3	3	3	4	4	4	4	4	5	5	5
6	0	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5	6	6
7	0	1	1	1	1	2	2	2	3	3	3	3	4	4	4	5	5	5	6	6	6	6	7	7
8	0	1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8
9	0	1	1	1	2	2	3	3	3	4	4	4	5	5	6	6	6	7	7	7	8	8	9	9
10	0	1	1	2	2	2	3	3	4	4	5	5	5	6	6	7	7	7	8	8	9	9	10	10
11	0	1	1	2	2	3	3	4	4	5	5	5	6	6	7	7	8	8	9	9	10	10	11	11
12	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12
13	1	1	2	2	3	3	4	4	5	5	6	6	7	8	8	9	9	10	10	11	11	12	12	13
14	1	1	2	2	3	3	4	5	5	6	6	7	8	8	9	9	10	10	11	12	12	13	13	14
15	1	1	2	2	3	4	4	5	6	6	7	7	8	9	9	10	11	11	12	12	13	14	14	15
16	1	1	2	3	3	4	5	5	6	7	7	8	9	9	10	11	11	12	13	13	14	15	15	16
17	1	1	2	3	4	4	5	6	6	7	8	8	9	10	11	11	12	13	13	14	15	16	16	17
18	1	1	2	3	4	4	5	6	7	7	8	9	10	10	11	12	13	13	14	15	16	16	17	18
19	1	2	2	3	4	5	6	6	7	8	9	9	10	11	12	13	13	14	15	16	17	17	18	19
20	1	2	2	3	4	5	6	7	7	8	9	10	11	12	12	13	14	15	16	17	17	18	19	20
21	1	2	3	3	4	5	6	7	8	9	10	10	11	12	13	14	15	16	17	17	18	19	20	21
22	1	2	3	4	5	5	6	7	8	9	10	11	12	13	14	15	16	16	17	18	19	20	21	22
23	1	2	3	4	5	6	7	8	9	10	11	11	12	13	14	15	16	17	18	19	20	21	22	23
24	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
25	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	19	20	21	22	23	24	25
26	1	2	3	4	5	6	8	9	10	11	12	13	14	15	16	17	18	19	21	22	23	24	25	26
27	1	2	3	4	6	7	8	9	10	11	12	13	15	16	17	18	19	20	21	22	24	25	26	27
28	1	2	3	5	6	7	8	9	10	12	13	14	15	16	17	19	20	21	22	23	24	26	27	28
29	1	2	4	5	6	7	8	10	11	12	13	14	16	17	18	19	21	22	23	24	25	27	28	29
30	1	2	4	5	6	7	9	10	11	12	14	15	16	17	19	20	21	22	24	25	26	27	29	30
31	1	3	4	5	6	8	9	10	12	13	14	15	17	18	19	21	22	23	25	26	27	28	30	31
32	1	3	4	5	7	8	9	11	12	13	15	16	17	19	20	21	23	24	25	27	28	29	31	32
33	1	3	4	5	7	8	10	11	12	14	15	16	18	19	21	22	23	25	26	27	29	30	32	33
34	1	3	4	6	7	8	10	11	13	14	16	17	18	20	21	23	24	25	27	28	30	31	33	34
35	1	3	4	6	7	9	10	12	13	15	16	17	19	20	22	23	25	26	28	29	31	32	34	35
36	1	3	4	6	7	9	10	12	13	15	16	18	19	21	22	24	25	27	28	30	31	33	34	36
37	2	3	5	6	8	9	11	12	14	15	17	18	20	22	23	25	26	28	29	31	32	34	35	37
38	2	3	5	6	8	9	11	13	14	16	17	19	21	22	24	25	27	28	30	32	33	35	36	38
39	2	3	5	6	8	10	11	13	15	16	18	19	21	23	24	26	28	29	31	32	34	36	37	39
40	2	3	5	7	8	10	12	13	15	17	18	20	22	23	25	27	28	30	32	33	35	37	38	40
41	2	3	5	7	9	10	12	14	15	17	19	20	22	24	26	27	29	31	32	34	36	38	39	41
42	2	3	5	7	9	10	12	14	16	17	19	21	23	24	26	28	30	31	33	35	37	38	40	42
43	2	4	5	7	9	11	13	14	16	18	20	21	23	25	27	29	30	32	34	36	38	39	41	43
44	2	4	5	7	9	11	13	15	16	18	20	22	24	26	27	29	31	33	35	37	38	40	42	44
45	2	4	6	7	9	11	13	15	17	19	21	22	24	26	28	30	32	34	36	37	39	41	43	45

Digitized by Google

TABLES XII, XIII, XIV, XV, and XVI.

TABLE XII.
The Refraction of the Heavenly Bodies in Altitude.

App. Alt.	Ref.	App. Alt.	Ref.	App. Alt.	Ref.
D. M.	M. S.	D. M.	M. S.	D.	M. S.
0. 0	33. 0	6.30	7.52	30	1.38
0. 5	32.11	6.40	7.41	31	1.35
0.10	31.22	6.50	7.31	32	1.31
0.15	30.36	7. 0	7.21	33	1.28
0.20	29.50	7.10	7.12	34	1.24
0.25	29. 6	7.20	7. 3	35	1.21
0.30	28.23	7.30	6.54	36	1.18
0.35	27.41	7.40	6.46	37	1.16
0.40	27. 0	7.50	6.38	38	1.13
0.45	26.20	8. 0	6.30	39	1.10
0.50	25.42	8.10	6.22	40	1. 8
0.55	25. 5	8.20	6.15	41	1. 5
1. 0	24.29	8.30	6. 8	42	1. 3
1. 5	23.54	8.40	6. 1	43	1. 1
1.10	23.20	8.50	5.55	44	0.59
1.15	22.47	9. 0	5.49	45	0.57
1.20	22.15	9.10	5.43	46	0.55
1.25	21.44	9.20	5.37	47	0.53
1.30	21.15	9.30	5.31	48	0.51
1.35	20.46	9.40	5.26	49	0.50
1.40	20.18	9.50	5.20	50	0.48
1.45	19.51	10. 0	5.15	51	0.46
1.50	19.25	10.15	5. 8	52	0.45
1.55	18.59	10.30	5. 0	53	0.43
2. 0	18.35	10.45	4.54	54	0.41
2. 5	18.11	11. 0	4.47	55	0.40
2.10	17.48	11.15	4.41	56	0.38
2.15	17.26	11.30	4.35	57	0.37
2.20	17. 4	11.45	4.29	58	0.36
2.25	16.44	12. 0	4.23	59	0.34
2.30	16.23	12.20	4.16	60	0.33
2.35	16. 4	12.40	4. 9	61	0.32
2.40	15.45	13. 0	4. 3	62	0.30
2.45	15.27	13.20	3.57	63	0.29
2.50	15. 9	13.40	3.51	64	0.28
2.55	14.52	14. 0	3.46	65	0.27
3. 0	14.35	14.20	3.40	66	0.25
3. 5	14.19	14.40	3.35	67	0.24
3.10	14. 3	15. 0	3.30	68	0.23
3.15	13.48	15.30	3.23	69	0.22
3.20	13.33	16. 0	3.17	70	0.21
3.25	13.19	16.30	3.11	71	0.20
3.30	13. 5	17. 0	3. 5	72	0.19
3.40	12.39	17.30	2.59	73	0.17
3.50	12.14	18. 0	2.54	74	0.16
4. 0	11.50	18.30	2.49	75	0.15
4.10	11.28	19. 0	2.44	76	0.14
4.20	11. 7	19.30	2.40	77	0.13
4.30	10.47	20. 0	2.36	78	0.12
4.40	10.28	20.30	2.32	79	0.11
4.50	10.10	21. 0	2.28	80	0.10
5. 0	9.53	21.30	2.24	81	0. 9
5.10	9.37	22. 0	2.20	82	0. 8
5.20	9.21	23. 0	2.14	83	0. 7
5.30	9. 7	24. 0	2. 7	84	0. 6
5.40	8.53	25. 0	2. 2	85	0. 5
5.50	8.39	26. 0	1.56	86	0. 4
6. 0	8.27	27. 0	1.51	87	0. 3
6.10	8.15	28. 0	1.47	88	0. 2
6.20	8. 3	29. 0	1.43	89	0. 1

TABLE XIII.
Depression or Dip of the Horizon of the Sea.

Height of the Eye.	Dip of the Horizon.
Feet.	M. S.
1	0.59
2	1.24
3	1.42
4	1.58
5	2.12
6	2.25
7	2.36
8	2.47
9	2.57
10	3. 7
11	3.16
12	3.25
13	3.33
14	3.41
15	3.49
16	3.56
17	4. 3
18	4.11
19	4.17
20	4.24
21	4.31
22	4.37
23	4.43
24	4.49
26	5. 1
28	5.13
30	5.23
35	5.49
40	6.14
45	6.36
50	6.58
60	7.37
70	8.14
80	8.48
90	9.20
100	9.51

TABLE XIV.
The Sun's Parallax in Altitude.

Sun's Alt.	Sun's Parallax.
D.	S.
0	9
10	9
20	8
30	8
40	7
50	6
55	5
60	4
65	4
70	3
75	2
80	2
85	1
90	0

TABLE XV.
Augmentation of the Moon's Semi-diameter.

Moon's Alt.	Augment.
D.	S.
0	0
5	1
10	3
15	4
20	5
25	7
30	8
35	9
40	10
45	11
50	12
55	13
60	14
70	15
80	15
90	16

TABLE XVI.
Dip of the Sea at different Distances from the Observer.

Dist of the Land in Sea Miles.	Height of the Eye above the Sea in Feet.							
	5	10	15	20	25	30	35	40
	Dip.	Dip.	Dip.	Dip.	Dip.	Dip.	Dip.	Dip.
	M.	M.	M.	M.	M.	M.	M.	M.
¼	11	23	34	45	57	68	79	91
½	6	12	17	23	28	34	40	45
¾	4	8	12	15	19	23	27	30
1	3	6	9	12	15	17	20	23
1¼	3	5	7	10	12	14	16	19
1½	3	4	6	8	10	12	14	16
2	2	4	5	7	8	9	11	12
2½	2	3	4	6	7	8	9	10
3	2	3	4	5	6	7	8	9
3½	2	3	4	5	6	6	7	8
4	2	3	4	5	5	6	7	7
5	2	3	4	4	5	6	6	7
6	2	3	4	4	5	5	6	6

NOTE TO TABLE XVI.—The numbers of this Table below the black lines, are the same as are given in Table XIII, the visible horizon, corresponding to those heights, not being so far distant as the land

Digitized by Google

TABLE XVII.

When a Star, or either of the Planets Jupiter or Saturn, is observed.

PARALLAX 0″.

*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.
5. 0	50. 8	0.9581	10. 0	54.45	1.2277	13.15	56. 2	1.3433	19. 0	57.16	1.4925	36.30	58.43	1.7517
10	50.24	0.9700	3	54.47	1.2297	20	56. 3	1.3459	10	57.17	1.4960	37. 0	58.45	1.7568
20	50.39	0.9817	6	54.48	1.2317	25	56. 5	1.3485	20	57.19	1.4996	30	58.46	1.7618
30	50.54	0.9930	9	54.50	1.2337	30	56. 6	1.3511	30	57.20	1.5031	38. 0	58.47	1.7668
40	51. 8	1.0041	12	54.51	1.2357	35	56. 8	1.3537	40	57.22	1.5066	30	58.49	1.7717
50	51.21	1.0150	15	54.53	1.2377	40	56. 9	1.3562	50	57.23	1.5101	39. 0	58.50	1.7766
6. 0	51.34	1.0255	10.18	54.54	1.2397	13.45	56.10	1.3587	20. 0	57.25	1.5136	39.30	58.51	1.7810
10	51.46	1.0360	21	54.56	1.2417	50	56.12	1.3612	10	57.26	1.5170	40. 0	58.52	1.7854
20	51.57	1.0462	24	54.57	1.2437	55	56.13	1.3637	20	57.27	1.5204	30	58.53	1.7900
30	52. 9	1.0562	27	54.58	1.2457	14. 0	56.15	1.3662	30	57.29	1.5238	41. 0	58.55	1.7946
40	52.19	1.0660	30	55. 0	1.2476	. 5	56.16	1.3687	40	57.30	1.5271	30	58.56	1.7987
50	52.29	1.0755	33	55. 1	1.2496	10	56.17	1.3711	50	57.31	1.5304	42. 0	58.57	1.8028
7. 0	52.39	1.0849	10.36	55. 3	1.2515	14.15	56.19	1.3735	21. 0	57.33	1.5338	42.30	58.58	1.8070
10	52.49	1.0941	39	55. 4	1.2534	20	56.20	1.3759	10	57.34	1.5370	43. 0	58.59	1.8112
20	52.58	1.1032	42	55. 5	1.2553	25	56.21	1.3783	20	57.35	1.5401	30	59. 0	1.8152
30	53. 6	1.1120	45	55. 7	1.2572	30	56.22	1.3807	30	57.36	1.5432	44. 0	59. 1	1.8192
35	53.11	1.1164	48	55. 8	1.2591	35	56 24	1.3831	40	57.37	1.5463	30	59. 2	1.8230
40	53.15	1.1207	51	55. 9	1.2610	40	56.25	1.3855	50	57.39	1.5494	45. 0	59. 3	1.8268
7.45	53.19	1.1250	10.54	55.11	1.2629	14.45	56.26	1.3878	22. 0	57.40	1.5525	46.	59. 5	1.8338
48	53.21	1.1275	57	55.12	1.2648	50	56.28	1.3901	10	57.41	1.5556	47.	59. 7	1.8411
51	53.24	1.1301	11. 0	55.13	1.2667	55	56.29	1.3924	20	57.42	1.5586	48.	59. 9	1.8478
54	53.26	1.1326	3	55.14	1.2686	15. 0	56.30	1.3947	30	57.43	1.5616	49.	59.11	1.8547
57	53.28	1.1351	6	55.16	1.2705	5	56.31	1.3970	40	57.44	1.5646	50.	59.12	1.8611
8. 0	53.30	1.1376	9	55.17	1.2724	10	56.32	1.3993	50	57.45	1.5676	51.	59.14	1.8670
8. 3	53.33	1.1401	11.12	55.18	1.2742	15.15	56.33	1.4016	23. 0	57.46	1.5706	52.	59.[illegible]6	[illegible]34
6	53.35	1.1425	15	55.19	1.2760	20	56.34	1.4039	10	57.47	1.5736	53.	59.17	1.8794
9	53.37	1.1450	18	55.21	1.2778	25	56.36	1.4061	20	57.49	1.5765	54.	59.19	1.8846
12	53.39	1.1474	21	55.22	1.2796	30	56.37	1.4083	30	57.50	1.5794	55.	59.20	1.8900
15	53.42	1.1499	24	55.23	1.2814	35	56.38	1.4105	40	57.51	1.5822	56.	59.22	1.8956
18	53.44	1.1523	27	55.24	1.2832	40	56.39	1.4127	50	57.52	1.5850	57.	59.23	1.9003
8.21	53.46	1.1547	11.30	55.25	1.2850	15.45	56.40	1.4149	24. 0	57.53	1.5879	58.	59.24	1.9050
24	53.48	1.1571	33	55.27	1.2868	50	56.41	1.4171	10	57.54	1.5907	59.	59.26	1.9102
27	53.50	1.1595	36	55.28	1.2886	55	56.42	1.4193	20	57.55	1.5935	60.	59.27	1.9142
30	53.52	1.1619	39	55.29	1.2904	16. 0	56.43	1.4214	30	57.56	1.5963	61.	59.28	1.9183
33	53.54	1.1642	42	55.30	1.2922	5	56.44	1.4236	40	57.56	1.5990	62.	59.30	1.9226
36	53.56	1.1666	45	55.31	1.2940	10	56.45	1.4258	50	57.57	1.6017	63.	59.31	1.9270
8.39	53.58	1.1689	11.48	55.32	1.2957	16.15	56.46	1.4279	25. 0	57.58	1.6044	64.	59.32	1.9302
42	54. 0	1.1712	51	55.34	1.2974	20	56.47	1.4300	20	58. 0	1.6097	65.	59.33	1.9335
45	54. 2	1.1735	54	55.35	1.2991	25	56.48	1.4321	40	58. 2	1.6149	66.	59.35	1.9369
48	54. 4	1.1758	57	55.36	1.3008	30	56.49	1.4342	26.00	58. 4	1.6201	67.	59.36	1.9404
51	54. 6	1.1781	12. 0	55.37	1.3025	35	56.50	1.4363	20	58. 5	1.6251	68.	59.37	1.9438
54	54.08	1.1804	3	55.38	1.3042	40	56.51	1.4384	40	58. 7	1.6301	69.	59.38	1.9471
8.57	54.10	1.1826	12. 6	55.39	1.3059	16.45	56.52	1.4405	27. 0	58. 9	1.6350	70.	59.39	1.9501
9. 0	54.12	1.1849	9	55.40	1.3076	50	56.53	1.4425	20	58.10	1.6400	71.	59.40	1.9528
3	54.13	1.1871	12	55.41	1.3093	55	56.54	1.4445	40	58.12	1.6449	72.	59.42	1.9553
6	54.15	1.1893	15	55.42	1.3110	17 0	56.55	1.4465	28. 0	58.13	1.6498	73.	59.43	1.9578
9	54.17	1.1916	18	55.43	1.3127	5	56.56	1.4486	20	58.15	1.6545	74.	59.44	1.9603
12	54.19	1.1938	21	55.44	1.3144	10	56.57	1.4506	40	58.16	1.6591	75.	59.45	1.9625
9.15	54.21	1.1960	12.24	55.45	1.3161	17.15	56.58	1.4526	29. 0	58.18	1.6635	76.	59.46	1.9643
18	54.22	1.1982	27	55.46	1.3178	20	56.59	1.4546	30	58.20	1.6702	77.	59.47	1.9660
21	54.24	1.2003	30	55.47	1.3194	25	57. 0	1.4566	30. 0	58.22	1.6769	78.	59.48	1.9676
24	54.26	1.2025	33	55.48	1.3211	30	57. 1	1.4586	30	58.24	1.6833	79.	59.49	1.9692
27	54.28	1.2047	36	55.49	1.3227	35	57. 2	1.4606	31. 0	58.25	1.6896	80.	59.50	1.9706
30	54.29	1.2068	39	55.50	1.3243	40	57. 3	1.4626	30	58.27	1.6957	81.	59.51	1.9714
9.33	54.31	1.2089	12.42	55.51	1.3259	17.45	57. 4	1.4646	32. 0	58.29	1.7018	82.	59.52	1.9722
36	54.33	1.2110	45	55.52	1.3275	50	57. 4	1.4665	30	58.31	1.7079	83.	59.53	1.9729
39	54.34	1.2132	48	55.53	1.3291	55	57. 5	1.4684	33. 0	58.33	1.7140	84.	59.54	1.9734
42	54.36	1.2153	51	55.54	1.3307	18 0	57. 6	1.4703	30	58.34	1.7202	85.	59.55	1.9737
45	54.37	1.2173	54	55.55	1.3323	10	57. 8	1.4741	34. 0	58.36	1.7262	86.	59.56	1.9739
48	54.39	1.2194	57	55.56	1.3339	20	57. 9	1.4778	30	58.37	1.7312	87.	59.57	1.9741
9.51	54.41	1.2215	13. 0	55.57	1.3355	18.30	57.11	1.4815	35. 0	58.39	1.7362	88.	59.58	1.9742
54	54.42	1.2236	5	55.59	1.3381	40	57.13	1.4852	30	58.40	1.7414	89.	59.59	1.9742
57	54.44	1.2257	10	56. 0	1.3407	50	57.14	1.4888	36. 0	58.42	1.7466	90.	60. 0	1.9742

Digitized by Google

TABLE XVII.

When the Planet Venus or Mars is used, and the Parallax is nearly equal to 5″

Parallax 5″.

*Ap. Alt. D M	Cor. M S	Log	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.
5. 0	50.13	0.9614	10. 0	54.50	1.2342	13.15	56.07	1.3521	19. 0	57.20	1.5049	36.30	58.47	1.7750
10	50.29	0.9733	3	54.52	1.2363	20	56.08	1.3547	10	57.22	1.5086	37. 0	58.49	1.7803
20	50.44	0.9851	6	54.53	1.2383	25	56.10	1.3574	20	57.23	1.5123	30	58.50	1.7855
30	50.59	0.9966	9	54.55	1.2404	30	56.11	1.3600	30	57.25	1.5159	38. 0	58.51	1.7907
40	51.13	1.0078	12	54.56	1.2425	35	56.12	1.3626	40	57.26	1.5195	30	58.52	1.7958
50	51.26	1.0188	15	54.58	1.2445	40	56.14	1.3652	50	57.28	1.5231	39. 0	58.54	1.8008
6. 0	51.39	1.0295	10.18	54.59	1.2465	13.45	56.15	1.3678	20. 0	57.29	1.5266	30	58.55	1.8056
10	51.51	1.0400	21	55.00	1.2485	50	56.17	1.3704	10	57.31	1.5301	40. 0	58.56	1.8104
20	52.03	1.0503	24	55.02	1.2505	55	56.18	1.3729	20	57.32	1.5336	30	58.57	1.8151
30	52.14	1.0604	27	55.03	1.2525	14. 0	56.19	1.3754	30	57.33	1.5371	41. 0	58.58	1.8198
40	52.24	1.0703	30	55.05	1.2545	5	56.21	1.3779	40	57.35	1.5405	30	59.00	1.8244
50	52.34	1.0800	33	55.06	1.2565	10	56.22	1.3804	50	57.36	1.5439	42. 0	59.01	1.8289
7. 0	52.44	1.0895	10.36	55.07	1.2585	14.15	56.23	1.3829	21. 0	57.37	1.5473	42.30	59.02	1.8333
10	52.54	1.0988	39	55.09	1.2605	20	56.25	1.3854	10	57.39	1.5507	43. 0	59.03	1.8376
20	53.03	1.1079	42	55.10	1.2624	25	56.26	1.3878	20	57.40	1.5540	30	59.04	1.8419
30	53.11	1.1169	45	55.12	1.2643	30	56.27	1.3902	30	57.41	1.5573	44. 0	59.05	1.8461
35	53.16	1.1213	48	55.13	1.2662	35	56.29	1.3927	40	57.42	1.5605	30	59.06	1.8502
40	53.20	1.1257	51	55.14	1.2681	40	56.30	1.3951	50	57.43	1.5637	45. 0	59.07	1.8543
7.45	53.24	1.1300	10.54	55.15	1.2701	14.45	56.31	1.3975	22. 0	57.44	1.5669	46.	59.09	1.8622
48	53.26	1.1326	57	55.17	1.2720	50	56.32	1.3999	10	57.46	1.5701	47.	59.10	1.8699
51	53.28	1.1352	11. 0	55.18	1.2739	55	56.34	1.4023	20	57.47	1.5733	48.	59.12	1.8773
54	53.30	1.1378	3	55.19	1.2758	15. 0	56.35	1.4046	30	57.48	1.5764	49.	59.14	1.8844
57	53.32	1.1404	6	55.21	1.2777	5	56.36	1.4070	40	57.49	1.5795	50.	59.15	1.8914
8. 0	53.35	1.1429	9	55.22	1.2796	10	56.37	1.4093	50	57.50	1.5826	51.	59.17	1.8981
8. 3	53.38	1.1454	11.12	55.23	1.2815	15.15	56.38	1.4116	23. 0	57.51	1.5857	52.	59.19	1.9045
6	53.40	1.1479	15	55.24	1.2833	20	56.39	1.4139	10	57.52	1.5887	53.	59.20	1.9107
9	53.42	1.1504	18	55.26	1.2852	25	56.40	1.4162	20	57.53	1.5917	54.	59.22	1.9167
12	53.44	1.1529	21	55.27	1.2871	30	56.41	1.4185	30	57.54	1.5947	55.	59.23	1.9226
15	53.47	1.1554	24	55.28	1.2889	35	56.43	1.4208	40	57.55	1.5977	56.	59.24	1.9282
18	53.49	1.1578	27	55.29	1.2907	40	56.44	1.4231	50	57.56	1.6007	57.	59.26	1.9336
8.21	53.51	1.1603	11.30	55.30	1.2925	15.45	56.45	1.4253	24. 0	57.57	1.6036	58.	59.27	1.9388
24	53.53	1.1627	33	55.32	1.2944	50	56.46	1.4276	10	57.58	1.6065	59.	59.28	1.9438
27	53.55	1.1651	36	55.33	1.2962	55	56.47	1.4298	20	57.59	1.6094	60.	59.30	1.9486
30	53.57	1.1675	39	55.34	1.2980	16. 0	56.48	1.4320	30	58.00	1.6122	61.	59.31	1.9532
33	53.59	1.1699	42	55.35	1.2998	5	56.49	1.4342	40	58.01	1.6151	62.	59.32	1.9577
36	54.01	1.1722	45	55.36	1.3016	10	56.50	1.4364	50	58.02	1.6179	63.	59.33	1.9619
8.39	54.03	1.1746	11.48	55.37	1.3033	16.15	56.51	1.4386	25. 0	58.03	1.6207	64.	59.34	1.9660
42	54.05	1.1770	51	55.38	1.3050	20	56.52	1.4408	20	58.05	1.6262	65.	59.36	1.9700
45	54.07	1.1793	54	55.39	1.3068	25	56.53	1.4430	40	58.06	1.6317	66.	59.37	1.9738
48	54.09	1.1817	57	55.41	1.3086	30	56.54	1.4451	26. 0	58.08	1.6371	67.	59.38	1.9773
51	54.11	1.1840	12. 0	55.42	1.3104	35	56.55	1.4472	20	58.10	1.6424	68.	59.39	1.9807
54	54.13	1.1863	3	55.43	1.3122	40	56.56	1.4493	40	58.11	1.6476	69.	59.40	1.9839
8.57	54.15	1.1886	12. 6	55.44	1.3139	16.45	56.57	[illegible]	27. 0	58.13	1.6527	70.	59.41	1.9870
9. 0	54.17	1.1908	9	55.45	1.3156	50	56.58	[illegible]	20	58.15	1.6578	71.	59.42	1.9899
3	54.18	1.1931	12	55.46	1.3173	55	56.59	1.4556	40	58.16	1.6629	72.	59.43	1.9927
6	54.20	1.1953	15	55.47	1.3190	17. 0	57.00	1.4577	28. 0	58.18	1.6678	73.	59.44	1.9953
9	54.22	1.1975	18	55.48	1.3207	5	57.01	1.4597	20	58.19	1.6727	74.	59.45	1.9977
12	54.24	1.1998	21	55.49	1.3224	10	57.02	1.4618	40	58.21	1.6775	75.	59.46	2.0000
9.15	54.25	1.2021	12.24	55.50	1.3242	17.15	57.03	1.4639	29. 0	58.22	1.6823	76.	59.47	2.0022
18	54.27	1.2043	27	55.51	1.3259	20	57.04	1.4660	30	58.24	1.6893	77.	59.48	2.0042
21	54.29	1.2065	30	55.52	1.3276	25	57.05	1.4680	30.00	58.26	1.6962	78.	59.49	2.0060
24	54.31	1.2087	33	55.53	1.3293	30	57.06	1.4700	30	58.28	1.7029	79.	59.50	2.0077
27	54.32	1.2109	36	55.54	1.3310	35	57.07	1.4720	31. 0	58.30	1.7095	80.	59.51	2.0092
30	54.34	1.2130	39	55.55	1.3326	40	57.07	1.4740	30	58.32	1.7160	81.	59.52	2.0106
9.33	54.36	1.2151	12.42	55.56	1.3343	17.45	57.08	1.4760	32. 0	58.33	1.7224	82.	59.53	2.0118
36	54.37	1.2173	45	55.57	1.3359	50	57.09	1.4780	30	58.35	1.7287	83.	59.54	2.0129
39	54.39	1.2195	48	55.58	1.3376	55	57.10	1.4800	33. 0	58.37	1.7349	84.	59.55	2.0139
42	54.41	1.2216	51	55.59	1.3392	18. 0	57.11	1.4820	30	58.38	1.7409	85.	59.55	2.0147
45	54.42	1.2237	54	56.00	1.3408	10	57.13	1.4859	34. 0	58.40	1.7468	86.	59.56	2.0153
48	54.44	1.2258	57	56.01	1.3424	20	57.14	1.4898	30	58.41	1.7526	87.	59.57	2.0158
9.51	54.45	1.2279	13. 0	56.02	1.3440	18.30	57.16	1.4936	35. 0	58.43	1.7584	88.	59.58	2.0162
54	54.47	1.2300	5	56.03	1.3468	40	57.17	1.4974	30	58.44	1.7640	89.	59.59	2.0164
57	54.49	1.2321	10	56.05	1.3495	50	57.19	1.5012	36. 0	58.46	1.7695	90.	60.00	2.0164

Digitized by Google

TABLE XVII.

When the Planet Venus or Mars is used, and the Parallax is nearly equal to 10″.

Parallax 10″.

*Ap. Alt.	Cor.	Log.	*Ap. Alt.	Cor.	Log.	*Ap. Alt.	Cor.	Log.	*Ap. Alt.	Cor.	Log.	*Ap. Alt.	Cor.	Log.
D M	M S		D M	M S		D M	M S		D M	M S		D M	M S	
5. 0	50.18	0.9650	10. 0	54.55	1.2412	13.15	56.11	1.3613	19. 0	57.25	1.5180	36.30	58.51	1.7996
10	50.33	0.9771	3	54.57	1.2433	20	56.13	1.3640	10	57.27	1.5218	37. 0	58.53	1.8052
20	50.48	0.9890	6	54.58	1.2454	25	56.14	1.3667	20	57.28	1.5256	30	58.54	1.8108
30	51.03	1.0006	9	55.00	1.2475	30	56.16	1.3693	30	57.30	1.5293	38. 0	58.55	1.8163
40	51.17	1.0119	12	55.01	1.2496	35	56.17	1.3720	40	57.31	1.5330	30	58.56	1.8217
50	51.31	1.0230	15	55.02	1.2516	40	56.19	1.3746	50	57.33	1.5367	39. 0	58.58	1.8269
6. 0	51.43	1.0338	10.18	55.04	1.2536	13.45	56.20	1.3773	20. 0	57.34	1.5404	39.30	58.59	1.8321
10	51.55	1.0444	21	55.05	1.2557	50	56.22	1.3799	10	57.35	1.5440	40. 0	59.00	1.8372
20	52.07	1.0549	24	55.07	1.2577	55	56.23	1.3825	20	57.37	1.5476	30	59.01	1.8422
30	52.18	1.0651	27	55.08	1.2597	14. 0	56.24	1.3851	30	57.38	1.5512	41. 0	59.02	1.8472
40	52.29	1.0751	30	55.10	1.2617	5	56.26	1.3877	40	57.39	1.5547	30	59.03	1.8521
50	52.39	1.0849	33	55.11	1.2638	10	56.27	1.3902	50	57.41	1.5582	42. 0	59.04	1.8569
7. 0	52.49	1.0945	10.36	55.12	1.2658	14.15	56.28	1.3927	21. 0	57.42	1.5617	42.30	59.05	1.8616
10	52.58	1.1039	39	55.14	1.2678	20	56.30	1.3952	10	57.43	1.5652	43. 0	59.06	1.8662
20	53.07	1.1131	42	55.15	1.2698	25	56.31	1.3977	20	57.44	1.5686	30	59.07	1.8708
30	53.15	1.1222	45	55.16	1.2718	30	56.32	1.4002	30	57.45	1.5720	44. 0	59.08	1.8753
35	53.19	1.1267	48	55.18	1.2737	35	56.33	1.4027	40	57.47	1.5754	30	59.09	1.8797
40	53.24	1.1311	51	55.19	1.2756	40	56.35	1.4052	50	57.48	1.5787	45. 0	59.10	1.8840
7.45	53.28	1.1355	10.54	55.20	1.2776	14.45	56.36	1.4077	22. 0	57.49	1.5820	46.	59.12	1.8925
48	53.31	1.1381	57	55.22	1.2795	50	56.37	1.4101	10	57.50	1.5853	47.	59.14	1.9007
51	53.33	1.1407	11. 0	55.23	1.2815	55	56.38	1.4125	20	57.51	1.5886	48.	59.15	1.9087
54	53.36	1.1433	3	55.24	1.2835	15. 0	56.39	1.4149	30	57.52	1.5919	49.	59.17	1.9164
57	53.38	1.1459	6	55.26	1.2854	5	56.41	1.4173	40	57.54	1.5951	50.	59.19	1.9238
8. 0	53.40	1.1485	9	55.27	1.2873	10	56.42	1.4197	50	57.55	1.5983	51.	59.20	1.9310
8. 3	53.43	1.1511	11.12	55.28	1.2892	15.15	56.43	1.4221	23. 0	57.56	1.6015	52.	59.22	1.9380
6	53.45	1.1536	15	55.29	1.2911	20	56.44	1.4245	10	57.57	1.6046	53.	59.23	1.9448
9	53.47	1.1561	18	55.30	1.2930	25	56.45	1.4269	20	57.58	1.6077	54.	59.25	1.9513
12	53.49	1.1586	21	55.32	1.2949	30	56.46	1.4292	30	57.59	1.6108	55.	59.26	1.9576
15	53.51	1.1611	24	55.33	1.2968	35	56.48	1.4315	40	58.00	1.6139	56.	59.27	1.9637
18	53.53	1.1636	27	55.34	1.2987	40	56.49	1.4338	50	58.01	1.6170	57.	59.28	1.9695
8.21	53.56	1.1661	11.30	55.35	1.3005	15.45	56.50	1.4361	24. 0	58.02	1.6200	58.	59.30	1.9751
24	53.58	1.1686	33	55.36	1.3024	50	56.51	1.4384	10	58.03	1.6230	59.	59.31	1.9806
27	54.00	1.1710	36	55.38	1.3042	55	56.52	1.4407	20	58.04	1.6260	60.	59.32	1.9858
30	54.02	1.1734	39	55.39	1.3060	16. 0	56.53	1.4430	30	58.05	1.6290	61.	59.33	1.9909
33	54.04	1.1758	42	55.40	1.3078	5	56.54	1.4453	40	58.06	1.6320	62.	59.34	1.9958
36	54.06	1.1782	45	55.41	1.3096	10	56.55	1.4476	50	58.07	1.6349	63.	59.36	2.0005
8.39	54.08	1.1806	11.48	55.42	1.3114	16.15	56.56	1.4498	25. 0	58.07	1.6378	64.	59.37	2.0049
42	54.10	1.1830	51	55.43	1.3133	20	56.57	1.4520	20	58.09	1.6435	65.	59.38	2.0092
45	54.12	1.1854	54	55.44	1.3151	25	56.58	1.4542	40	58.11	1.6492	66.	59.39	2.0133
48	54.14	1.1878	57	55.45	1.3169	30	56.59	1.4564	26. 0	58.13	1.6548	67.	59.40	2.0172
51	54.16	1.1901	12. 0	55.47	1.3187	35	57.00	1.4586	20	58.14	1.6604	68.	59.41	2.0209
54	54.18	1.1925	3	55.48	1.3205	40	57.01	1.4608	40	58.16	1.6659	69.	59.42	2.0245
8.57	54.20	1.1948	12. 6	55.49	1.3223	16.45	57.02	1.4630	27. 0	58.17	1.6712	70.	59.43	2.0279
9. 0	54.22	1.1971	9	55.50	1.3241	50	57.03	1.4652	20	58.19	1.6765	71.	59.44	2.0311
3	54.23	1.1994	12	55.51	1.3258	55	57.04	1.4673	40	58.21	1.6818	72.	59.45	2.0341
6	54.25	1.2017	15	55.52	1.3275	17. 0	57.05	1.4694	28. 0	58.22	1.6870	73.	59.46	2.0370
9	54.27	1.2040	18	55.53	1.3293	5	57.06	1.4716	20	58.24	1.6921	74.	59.46	2.0397
12	54.29	1.2063	21	55.54	1.3310	10	57.07	1.4737	40	58.25	1.6971	75.	59.47	2.0422
9.15	54.30	1.2085	12.24	55.55	1.3327	17.15	57.08	1.4758	29. 0	58.26	1.7021	76.	59.48	2.0446
18	54.32	1.2108	27	55.56	1.3345	20	57.09	1.4779	30	58.28	1.7094	77.	59.49	2.0468
21	54.34	1.2131	30	55.57	1.3362	25	57.10	1.4800	30. 0	58.30	1.7166	78.	59.50	2.0488
24	54.36	1.2153	33	55.58	1.3379	30	57.10	1.4821	30	58.32	1.7237	79.	59.51	2.0507
27	54.37	1.2175	36	55.59	1.3396	35	57.11	1.4842	31. 0	58.34	1.7307	80.	59.52	2.0524
30	54.39	1.2197	39	56.00	1.3413	40	57.12	1.4863	30	58.36	1.7375	81.	59.53	2.0539
9.33	54.41	1.2219	12.42	56.01	1.3430	17.45	57.13	1.4883	32. 0	58.38	1.7442	82.	59.53	2.0553
36	54.42	1.2241	45	56.02	1.3447	50	57.14	1.4904	30	58.39	1.7508	83.	59.54	2.0565
39	54.44	1.2263	48	56.03	1.3464	55	57.15	1.4924	33. 0	58.41	1.7573	84.	59.55	2.0575
42	54.46	1.2285	51	56.04	1.3481	18. 0	57.16	1.4944	30	58.43	1.7637	85.	59.56	2.0584
45	54.47	1.2306	54	56.05	1.3498	10	57.17	1.4984	34. 0	58.44	1.7699	86.	59.57	2.0592
48	54.49	1.2328	57	56.06	1.3514	20	57.19	1.5024	30	58.46	1.7760	87.	59.58	2.0597
9.51	54.50	1.2349	13. 0	56.07	1.3530	18.30	57.21	1.5063	35. 0	58.47	1.7821	88.	59.58	2.0601
54	54.52	1.2370	5	56.08	1.3558	40	57.22	1.5102	30	58.49	1.7881	89.	59.59	2.0603
57	54.54	1.2391	10	56.10	1.3586	50	57.24	1.5141	36. 0	58.50	1.7939	90.	60.00	2.0603

TABLE XVII.

When the Planet Venus or Mars is used, and the Parailax is nearly equal to 15″.

PARALLAX 15″.

*Ap. Alt.	Cor.	Log.	*Ap. Alt.	Cor.	Log.	*Ap. Alt.	Cor.	Log.	*Ap. Alt.	Cor.	Log.	*Ap. Alt.	Cor.	Log.
D M	M S		D M	M S		D M	M S		D M	M S		D M	M S	
5. 0	50.22	0.9688	10. 0	55.00	1.2483	13.15	56.16	1.3706	19. 0	57.30	1.5314	36.30	58.55	1.8257
10	50.38	0.9810	3	55.02	1.2504	20	56.18	1.3734	10	57.31	1.5353	37. 0	58.57	1.8317
20	50.53	0.9929	6	55.03	1.2525	25	56.19	1.3762	20	57.33	1.5392	30	58.58	1.8376
30	51.08	1.0046	9	55.05	1.2546	30	56.21	1.3789	30	57.34	1.5431	38. 0	58.59	1.8434
40	51.22	1.0160	12	55.06	1.2567	35	56.22	1.3816	40	57.36	1.5470	30	59.00	1.8491
50	51.35	1.0272	15	55.07	1.2588	40	56.24	1.3843	50	57.37	1.5508	39. 0	59.02	1.8548
6. 0	51.48	1.0382	10.18	55.09	1.2609	13.45	56.25	1.3870	20. 0	57.39	1.5546	39.30	59.03	1.8603
10	52.00	1.0490	21	55.10	1.2630	50	56.26	1.3897	10	57.40	1.5583	40. 0	59.04	1.8658
20	52.12	1.0595	24	55.12	1.2651	55	56.28	1.3923	20	57.41	1.5620	30	59.05	1.8712
30	52.23	1.0698	27	55.13	1.2672	14. 0	56.29	1.3949	30	57.43	1.5657	41. 0	59.06	1.8765
40	52.34	1.0799	30	55.15	1.2693	5	56.30	1.3975	40	57.44	1.5694	30	59.07	1.8817
50	52.44	1.0898	33	55.16	1.2713	10	56.32	1.4001	50	57.45	1.5730	42. 0	59.08	1.8868
7. 0	52.54	1.0995	10.36	55.17	1.2733	14.15	56.33	1.4027	21. 0	57.47	1.5766	42.30	59.09	1.8918
10	53.03	1.1090	39	55.19	1.2754	20	56.34	1.4053	10	57.48	1.5802	43. 0	59.10	1.8968
20	53.12	1.1184	42	55.20	1.2774	25	56.36	1.4079	20	57.49	1.5837	30	59.11	1.9017
30	53.21	1.1276	45	55.21	1.2794	30	56.37	1.4105	30	57.50	1.5872	44. 0	59.12	1.9065
35	53.25	1.1322	48	55.23	1.2814	35	56.38	1.4130	40	57.51	1.5907	30	59.13	1.9112
40	53.29	1.1366	51	55.24	1.2834	40	56.40	1.4155	50	57.53	1.5942	45. 0	59.14	1.9159
7.45	53.34	1.1410	10.54	55.25	1.2854	14.45	56.41	1.4180	22. 0	57.54	1.5977	46.	59.15	1.9251
48	53.36	1.1437	57	55.27	1.2874	50	56.42	1.4205	10	57.55	1.6011	47.	59.17	1.9340
51	53.38	1.1464	11. 0	55.28	1.2893	55	56.43	1.4230	20	57.56	1.6045	48.	59.19	1.9426
54	53.41	1.1490	3	55.29	1.2913	15. 0	56.44	1.4255	30	57.57	1.6079	49.	59.20	1.9509
57	53.43	1.1516	6	55.30	1.2933	5	56.46	1.4279	40	57.58	1.6112	50.	59.22	1.9590
8. 0	53.45	1.1542	9	55.32	1.2952	10	56.47	1.4304	50	57.59	1.6145	51.	59.23	1.9668
8. 3	53.48	1.1567	11.12	55.33	1.2971	15.15	56.48	1.4329	23. 0	58.00	1.6178	52.	59.25	1.9744
6	53.50	1.1593	15	55.34	1.2990	20	56.49	1.4353	10	58.01	1.6211	53.	59.26	1.9817
9	53.52	1.1619	18	55.35	1.3010	25	56.50	1.4377	20	58.02	1.6244	54.	59.27	1.9888
12	53.54	1.1644	21	55.37	1.3029	30	56.51	1.4401	30	58.03	1.6276	55.	59.29	1.9957
15	53.57	1.1669	24	55.38	1.3048	35	56.52	1.4425	40	58.04	1.6308	56.	59.30	2.0023
18	53.59	1.1695	27	55.39	1.3067	40	56.53	1.4449	50	58.05	1.6340	57.	59.31	2.0087
8.21	54.01	1.1720	11.30	55.40	1.3086	15.45	56.54	1.4473	24. 0	58.06	1.6371	58.	59.32	2.0149
24	54.03	1.1745	33	55.41	1.3105	50	56.56	1.4497	10	58.07	1.6402	59.	59.34	2.0209
27	54.05	1.1770	36	55.42	1.3124	55	56.57	1.4520	20	58.08	1.6433	60.	59.35	2.0267
30	54.07	1.1795	39	55.44	1.3143	16. 0	56.58	1.4543	30	58.09	1.6464	61.	59.36	2.0322
33	54.09	1.1819	42	55.45	1.3162	5	56.59	1.4566	40	58.10	1.6495	62.	59.37	2.0375
36	54.11	1.1843	45	55.46	1.3180	10	57.00	1.4589	50	58.11	1.6526	63.	59.38	2.0427
8.39	54.13	1.1868	11.48	55.47	1.3198	16.15	57.01	1.4612	25. 0	58.12	1.6556	64.	59.39	2.0476
42	54.15	1.1892	51	55.48	1.3217	20	57.02	1.4635	20	58.14	1.6616	65.	59.40	2.0523
45	54.17	1.1916	54	55.49	1.3235	25	57.03	1.4658	40	58.16	1.6675	66.	59.41	2.0568
48	54.19	1.1940	57	55.50	1.3253	30	57.04	1.4681	26. 0	58.17	1.6734	67.	59.42	2.0612
51	54.21	1.1964	12. 0	55.51	1.3271	35	57.05	1.4704	20	58.19	1.6792	68.	59.43	2.0654
54	54.23	1.1988	3	55.53	1.3289	40	57.06	1.4726	40	58.20	1.6849	69.	59.44	2.0693
8.57	54.25	1.2012	12. 6	55.54	1.3307	16.45	57.07	1.4748	27. 0	58.22	1.6905	70.	59.44	2.0730
9. 0	54.26	1.2035	9	55.55	1.3325	50	57.08	1.4770	20	58.24	1.6960	71.	59.45	2.0766
3	54.28	1.2058	12	55.56	1.3343	55	57.09	1.4792	40	58.25	1.7015	72.	59.46	2.0800
6	54.30	1.2081	15	55.57	1.3361	17. 0	57.10	1.4814	28. 0	58.26	1.7069	73.	59.47	2.0832
9	54.32	1.2104	18	55.58	1.3379	5	57.11	1.4836	20	58.28	1.7123	74.	59.48	2.0862
12	54.34	1.2127	21	55.59	1.3397	10	57.12	1.4858	40	58.29	1.7176	75.	59.49	2.0890
9.15	54.35	1.2150	12.24	56.00	1.3415	17.15	57.12	1.4880	29. 0	58.31	1.7228	76.	59.49	2.0916
18	54.37	1.2173	27	56.01	1.3433	20	57.13	1.4902	30	58.33	1.7305	77.	59.50	2.0940
21	54.39	1.2196	30	56.02	1.3450	25	57.14	1.4924	30. 0	58.35	1.7381	78.	59.51	2.0962
24	54.41	1.2219	33	56.03	1.3468	30	57.15	1.4945	30	58.37	1.7456	79.	59.52	2.0983
27	54.42	1.2242	36	56.04	1.3485	35	57.16	1.4966	31. 0	58.38	1.7529	80.	59.53	2.1003
30	54.44	1.2264	39	56.05	1.3503	40	57.17	1.4987	30	58.40	1.7601	81.	59.53	2.1021
9.33	54.46	1.2286	12.42	56.06	1.3520	17.45	57.18	1.5008	32. 0	58.42	1.7671	82.	59.54	2.1036
36	54.47	1.2308	45	56.07	1.3537	50	57.19	1.5029	30	58.44	1.7740	83.	59.55	2.1049
39	54.49	1.2330	48	56.08	1.3554	55	57.19	1.5050	33. 0	58.45	1.7809	84.	59.56	2.1060
42	54.51	1.2352	51	56.09	1.3571	18. 0	57.20	1.5071	30	58.47	1.7876	85.	59.56	2.1070
45	54.52	1.2374	54	56.10	1.3588	10	57.22	1.5112	34. 0	58.48	1.7942	86.	59.57	2.1078
48	54.54	1.2396	57	56.11	1.3605	20	57.24	1.5153	30	58.50	1.8007	87.	59.58	2.1084
9.51	54.55	1.2418	13. 0	56.12	1.3622	18.30	57.25	1.5194	35. 0	58.51	1.8071	88.	59.59	2.1089
54	54.57	1.2440	5	56.13	1.3650	40	57.27	1.5235	30	58.53	1.8134	89.	59.59	2.1092
57	54.58	1.2461	10	56.15	1.3678	50	57.29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Digitized by Google

TABLE XVII.

When the Planet Venus or Mars is used, and the Parallax is nearly equal to 20″.

PARALLAX 20″.

*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.
5. 0	50.27	0.9725	10. 0	55.05	1.2554	13.15	56.21	1.3802	19. 0	57.35	1.5453	36.30	58.59	1.8535
10	50.43	0.9848	3	55.06	1.2576	20	56.22	1.3830	10	57.37	1.5494	37. 0	59.01	1.8599
20	50.58	0.9969	6	55.08	1.2597	25	56.23	1.3858	20	57.38	1.5534	30	59.02	1.8662
30	51.13	1.0087	9	55.09	1.2619	30	56.25	1.3886	30	57.39	1.5574	38. 0	59.03	1.8724
40	51.27	1.0202	12	55.11	1.2640	35	56.27	1.3914	40	57.41	1.5614	30	59.04	1.8785
50	51.40	1.0315	15	55.12	1.2662	40	56.28	1.3941	50	57.42	1.5653	39. 0	59.05	1.8846
6. 0	51.53	1.0426	10.18	55.14	1.2683	13.45	56.30	1.3969	20. 0	57.43	1.5692	39 30	59.06	1.8906
10	52.05	1.0535	21	55.15	1.2704	50	56.31	1.3996	10	57.45	1.5731	40. 0	59.07	1.8964
20	52.17	1.0641	24	55.17	1.2725	55	56.32	1.4023	20	57.46	1.5770	30	59.09	1.9021
30	52.28	1.0745	27	55.18	1.2746	14. 0	56.33	1.4050	30	57.47	1.5808	41. 0	59.10	1.9078
40	52.39	1.0847	30	55.20	1.2767	5	56.34	1.4077	40	57.49	1.5846	30	59.11	1.9134
50	52.49	1.0947	33	55.21	1.2788	10	56.36	1.4104	50	57.50	1.5884	42. 0	59.12	1.9189
7. 0	52.59	1.1046	10.36	55.22	1.2809	14.15	56.38	1.4131	21. 0	57.51	1.5921	42.30	59.13	1.9243
10	53.08	1.1142	39	55.24	1.2830	20	56.39	1.4157	10	57.53	1.5958	43. 0	59.14	1.9297
20	53.17	1.1237	42	55.25	1.2851	25	56.40	1.4183	20	57.54	1.5995	30	59.15	1.9350
30	53.26	1.1330	45	55.26	1.2871	30	56.42	1.4209	30	57.55	1.6031	44. 0	59.15	1.9402
35	53.30	1.1376	48	55.28	1.2891	35	56.43	1.4235	40	57.56	1.6067	30	59.16	1.9454
40	53.35	1.1422	51	55.29	1.2911	40	56.44	1.4261	50	57.57	1.6103	45. 0	59.17	1.9504
7.45	53.39	1.1467	10.54	55.30	1.2932	14.45	56.46	1.4287	22. 0	57.58	1.6139	46.	59.19	1.9604
48	53.41	1.1494	57	55.32	1.2952	50	56.47	1.4313	10	57.59	1.6175	47.	59.21	1.9700
51	53.43	1.1520	11. 0	55.33	1.2972	55	56.48	1.4339	20	58.01	1.6210	48.	59.22	1.9793
54	53.46	1.1547	3	55.34	1.2992	15. 0	56.49	1.4364	30	58.02	1.6245	49.	59.24	1.9884
57	53.48	1.1574	6	55.35	1.3012	5	56.50	1.4389	40	58.03	1.6280	50.	59.25	1.9972
8. 0	53.50	1.1600	9	55.37	1.3032	10	56.52	1.4414	50	58.04	1.6314	51.	59.27	2.0057
8. 3	53.53	1.1626	11.12	55.38	1.3052	15.15	56.53	1.4439	23. 0	58.05	1.6348	52.	59.28	2.0140
6	53.55	1.1652	15	55.39	1.3071	20	56.54	1.4464	10	58.06	1.6382	53.	59.29	2.0221
9	53.57	1.1678	18	55.40	1.3091	25	56.55	1.4489	20	58.07	1.6416	54.	59.30	2.0299
12	53.59	1.1704	21	55.42	1.3111	30	56.56	1.4514	30	58.08	1.6450	55.	59.32	2.0374
15	54.01	1.1729	24	55.43	1.3130	35	56.57	1.4539	40	58.09	1.6483	56.	59.33	2.0447
18	54.04	1.1755	27	55.44	1.3149	40	56.58	1.4563	50	58.10	1.6516	57.	59.34	2.0518
8.21	54.06	1.1780	11.30	55.45	1.3168	15.45	56.59	1.4587	24. 0	58.11	1.6549	58.	59.35	2.0587
24	54.08	1.1805	33	55.46	1.3187	50	57.01	1.4611	10	58.12	1.6582	59.	59.36	2.0653
27	54.10	1.1830	36	55.47	1.3206	55	57.02	1.4635	20	58.13	1.6615	60.	59.37	2.0717
30	54.12	1.1855	39	55.49	1.3225	16. 0	57.03	1.4659	30	58.14	1.6647	61.	59.38	2.0779
33	54.14	1.1880	42	55.50	1.3245	5	57.04	1.4683	40	58.15	1.6679	62.	59.39	2.0838
36	54.16	1.1905	45	55.51	1.3264	10	57.05	1.4707	50	58.16	1.6711	63.	59.40	2.0895
8.39	54.18	1.1930	11.48	55.52	1.3283	16.15	57.06	1.4730	25. 0	58.16	1.6742	64.	59.41	2.0950
42	54.20	1.1955	51	55.53	1.3302	20	57.07	1.4754	20	58.18	1.6805	65.	59.42	2.1003
45	54.22	1.1979	54	55.54	1.3321	25	57.08	1.4777	40	58.20	1.6867	66.	59.43	2.1054
48	54.24	1.2004	57	55.55	1.3340	30	57.09	1.4800	26. 0	58.22	1.6928	67.	59.44	2.1102
51	54.26	1.2028	12. 0	55.56	1.3358	35	57.10	1.4823	20	58.23	1.6988	68.	59.45	2.1148
54	54.28	1.2052	3	55.57	1.3377	40	57.11	1.4846	40	58.25	1.7047	69.	59.45	2.1192
8.57	54.30	1.2076	12. 6	55.59	1.3396	16.45	57.12	1.4869	27. 0	58.26	1.7106	70.	59.46	2.1234
9. 0	54.31	1.2100	9	56.00	1.3414	50	57.13	1.4892	20	58.28	1.7164	71.	59.47	2.1274
3	54.33	1.2124	12	56.01	1.3432	55	57 14	1.4915	40	58.30	1.7222	72.	59.48	2.1312
6	54.35	1.2147	15	56.02	1.3450	17. 0	57.14	1.4938	28. 0	58.31	1.7279	73.	59.48	2.1348
9	54.37	1.2170	18	56.03	1.3468	5	57.15	1.4961	20	58.32	1.7335	74.	59.49	2.1382
12	54.39	1.2194	21	56.04	1.3486	10	57.16	1.4983	40	58.34	1.7391	75.	59.50	2.1414
9.15	54.40	1.2217	12.24	56.05	1.3504	17.15	57.17	1.5005	29. 0	58.35	1.7446	76.	59.51	2.1444
18	54.42	1.2240	27	56.06	1.3522	20	57.18	1.5028	30	58.37	1.7527	77.	59.51	2.1471
21	54.44	1.2263	30	56.07	1.3540	25	57.19	1.5050	30. 0	58.39	1.7607	78.	59.52	2.1496
24	54.46	1.2286	33	56.08	1.3558	30	57.20	1.5072	30	58.41	1.7685	79.	59.53	2.1520
27	54.47	1.2309	36	56.09	1.3576	35	57.21	1.5094	31. 0	58.43	1.7762	80.	59.54	2.1542
30	54.49	1.2332	39	56.10	1.3594	40	57.22	1.5116	30	58.44	1.7838	81.	59.54	2.1561
9.33	54.51	1.2355	12.42	56.11	1.3612	17 45	57.23	1.5137	32. 0	58.46	1.7913	82.	59.55	2.1578
36	54.52	1.2377	45	56.12	1.3629	50	57.23	1.5159	30	58.48	1.7987	83.	59.55	2.1594
39	54.54	1.2400	48	56.13	1 3647	55	57.24	1.5181	33. 0	58.49	1.8059	84.	59.56	2.1607
42	54.56	1.2423	51	56.14	1.3664	18. 0	57.25	1.5202	30	58.51	1.8130	85.	59.57	2 1618
45	54.57	1.2445	54	56.15	1.3681	10	57.27	1.5245	34. 0	58.52	1.8200	86.	59.57	2 1627
43	54.59	1.2467	57	56.16	1.3698	20	57.28	1.5287	30	58.54	1.8269	87.	59.58	2.1634
9.51	55.00	1.2489	13. 0	56.17	1.3715	18.30	57.30	1.5329	35. 0	58.55	1.8337	88.	59.59	2.1639
54	55.02	1.2511	5	56.18	1.3744	40	57.32	1.5371	30	58.57	1.8404	89.	59.59	2.1642
57	55.03	1.2533	10	56.20	1.3773	50	57.33	1.5412	36. 0	58.58	1.8470	90.	60.00	2.1643

TABLE XVII.

When the Planet Venus or Mars is used, and the Parallax is nearly equal to 25″.

Parallax 25″.

*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.
5. 0	50.32	0.9763	10. 0	55.10	1.2628	13.15	56.26	1.3899	19. 0	57.39	1.5597	36.30	59.03	1.8832
10	50.48	0.9887	3	55.11	1.2650	20	56.28	1.3928	10	57.41	1.5639	37. 0	59.05	1.8901
20	51.03	1.0009	6	55.13	1.2671	25	56.29	1.3957	20	57.42	1.5681	30	59.06	1.8968
30	51.18	1.0128	9	55.14	1.2693	30	56.31	1.3985	30	57.44	1.5722	38. 0	59.07	1.9035
40	51.32	1.0245	12	55.16	1.2715	35	56.32	1.4014	40	57.45	1.5763	30	59.08	1.9100
50	51.45	1.0359	15	55.17	1.2737	40	56.33	1.4042	50	57.47	1.5804	39. 0	59.09	1.9165
6. 0	51.58	1.0471	10.18	55.19	1.2759	13.45	56.35	1.4070	20. 0	57.48	1.5844	39.30	59.10	1.9229
10	52.11	1.0581	21	55.20	1.2781	50	56.36	1.4098	10	57.49	1.5884	40. 0	59.11	1.9292
20	52.22	1.0688	24	55.22	1.2802	55	56.38	1.4126	20	57.51	1.5924	30	59.12	1.9354
30	52.34	1.0793	27	55.23	1.2823	14. 0	56.39	1.4154	30	57.52	1.5964	41. 0	59.13	1.9416
40	52.44	1.0896	30	55.24	1.2844	5	56.40	1.4182	40	57.53	1.6003	30	59.14	1.9477
50	52.54	1.0998	33	55.26	1.2865	10	56.42	1.4209	50	57.55	1.6042	42. 0	59.15	1.9537
7. 0	53.04	1.1098	10.36	55.27	1.2886	14.15	56.43	1.4236	21. 0	57.56	1.6081	42.30	59.16	1.9596
10	53.13	1.1195	39	55.29	1.2907	20	56.44	1.4263	10	57.57	1.6119	43. 0	59.17	1.9654
20	53.22	1.1291	42	55.30	1.2928	25	56.45	1.4290	20	57.58	1.6157	30	59.18	1.9711
30	53.31	1.1385	45	55.31	1.2949	30	56.47	1.4317	30	58.00	1.6195	44. 0	59.19	1.9768
35	53.35	1.1432	48	55.33	1.2970	35	56.48	1.4344	40	58.01	1.6233	30	59.20	1.9824
40	53.40	1.1478	51	55.34	1.2991	40	56.49	1.4370	50	58.02	1.6271	45. 0	59.21	1.9879
7.45	53.44	1.1522	10.54	55.35	1.3012	14.45	56.50	1.4397	22. 0	58.03	1.6308	46.	59.22	1.9987
48	53.46	1.1550	57	55.36	1.3032	50	56.52	1.4423	10	58.04	1.6345	47.	59.24	2.0092
51	53.48	1.1577	11. 0	55.38	1.3052	55	56.53	1.4449	20	58.05	1.6382	48.	59.25	2.0194
54	53.51	1.1604	3	55.39	1.3073	15. 0	56.54	1.4475	30	58.06	1.6418	49.	59.27	2.0294
57	53.53	1.1631	6	55.40	1.3093	5	56.55	1.4501	40	58.07	1.6454	50.	59.28	2.0391
8. 0	53.55	1.1658	9	55.41	1.3113	10	56.56	1.4527	50	58.08	1.6490	51.	59.30	2.0485
8. 3	53.58	1.1684	11.12	55.43	1.3133	15.15	56.57	1.4552	23. 0	58.09	1.6526	52.	59.31	2.0577
6	54.00	1.1711	15	55.44	1.3153	20	56.59	1.4578	10	58.10	1.6561	53.	59.32	2.0666
9	54.02	1.1737	18	55.45	1.3173	25	57.00	1.4604	20	58.11	1.6596	54.	59.33	2.0752
12	54.04	1.1763	21	55.46	1.3193	30	57.01	1.4629	30	58.12	1.6631	55.	59.34	2.0836
15	54.06	1.1790	24	55.48	1.3213	35	57.02	1.4654	40	58.13	1.6666	56.	59.36	2.0918
18	54.09	1.1816	27	55.49	1.3233	40	57.03	1.4679	50	58.14	1.6701	57.	59.37	2.0997
8.21	54.11	1.1842	11.30	55.50	1.3253	15.45	57.04	1.4704	24. 0	58.15	1.6735	58.	59.38	2.1073
24	54.13	1.1868	33	55.51	1.3272	50	57.05	1.4729	10	58.16	1.6769	59.	59.39	2.1147
27	54.15	1.1893	36	55.52	1.3292	55	57.06	1.4754	20	58.17	1.6803	60.	59.40	2.1219
30	54.17	1.1918	39	55.53	1.3311	16. 0	57.07	1.4778	30	58.18	1.6837	61.	59.41	2.1288
33	54.19	1.1943	42	55.55	1.3331	5	57.08	1.4803	40	58.19	1.6870	62.	59.41	2.1355
36	54.21	1.1968	45	55.56	1.3350	10	57.09	1.4827	50	58.20	1.6903	63.	59.42	2.1419
8.39	54.23	1.1993	11.48	55.57	1.3370	16.15	57.10	1.4852	25. 0	58.21	1.6936	64.	59.43	2.1481
42	54.25	1.2018	51	55.58	1.3389	20	57.11	1.4876	20	58.23	1.7002	65.	59.44	2.1541
45	54.27	1.2043	54	55.59	1.3408	25	57.12	1.4900	40	58.25	1.7067	66.	59.45	2.1599
48	54.29	1.2068	57	56.00	1.3427	30	57.13	1.4924	26. 0	58.26	1.7131	67.	59.46	2.1654
51	54.31	1.2092	12. 0	56.01	1.3446	35	57.14	1.4948	20	58.28	1.7194	68.	59.46	2.1707
54	54.33	1.2117	3	56.02	1.3465	40	57.15	1.4972	40	58.29	1.7256	69.	59.47	2.1757
8.57	54.35	1.2141	12. 6	56.03	1.3484	16.45	57.16	1.4995	27. 0	58.31	1.7318	70.	59.48	2.1805
9. 0	54.36	1.2165	9	56.04	1.3502	50	57.17	1.5019	20	58.32	1.7379	71.	59.49	2.1851
3	54.38	1.2189	12	56.05	1.3521	55	57.18	1.5042	40	58.34	1.7440	72.	59.49	2.1894
6	54.40	1.2213	15	56.06	1.3539	17. 0	57.19	1.5065	28. 0	58.35	1.7500	73.	59.50	2.1935
9	54.42	1.2237	18	56.08	1.3558	5	57.20	1.5088	20	58.37	1.7559	74.	59.51	2.1973
12	54.43	1.2261	21	56.09	1.3577	10	57.21	1.5111	40	58.38	1.7617	75.	59.51	2.2009
9.15	54.45	1.2285	12.24	56.10	1.3596	17.15	57.22	1.5134	29. 0	58.39	1.7675	76.	59.52	2.2043
18	54.47	1.2309	27	56.11	1.3614	20	57.23	1.5157	30	58.41	1.7760	77.	59.53	2.2075
21	54.49	1.2333	30	56.12	1.3632	25	57.24	1.5180	30. 0	58.43	1.7845	78.	59.53	2.2105
24	54.51	1.2356	33	56.13	1.3650	30	57.25	1.5203	30	58.45	1.7928	79.	59.54	2.2132
27	54.52	1.2379	36	56.14	1.3668	35	57.26	1.5226	31. 0	58.47	1.8010	80.	59.54	2.2156
30	54.54	1.2402	39	56.15	1.3686	40	57.27	1.5249	30	58.49	1.8090	81.	59.55	2.2178
9.33	54.56	1.2425	12.42	56.16	1.3704	17.45	57.27	1.5271	32. 0	58.50	1.8169	82.	59.56	2.2198
36	54.57	1.2448	45	56.17	1.3722	50	57.28	1.5293	30	58.52	1.8247	83.	59.56	2.2216
39	54.59	1.2471	48	56.18	1.3740	55	57.29	1.5315	33. 0	58.54	1.8324	84.	59.57	2.2232
42	55.00	1.2494	51	56.19	1.3758	18. 0	57.30	1.5337	30	58.55	1.8400	85.	59.57	2.2245
45	55.02	1.2516	54	56.20	1.3776	10	57.32	1.5381	34. 0	58.56	1.8474	86.	59.58	2.2256
48	55.04	1.2538	57	56.21	1.3794	20	57.33	1.5425	30	58.58	1.8547	87.	59.58	2.2264
9.51	55.05	1.2561	13. 0	56.21	1.3811	18.30	57.35	1.5468	35. 0	58.59	1.8620	88.	59.59	2.2269
54	55.07	1.2584	5	56.23	1.3841	40	57.36	1.5511	30	59.01	1.8692	89.	59.59	2.2273
57	55.08	1.2606	10	56.25	1.3870	50	57.38	1.5554	36. 0	59.02	1.8763	90.	60.00	2.2274

Digitized by Google

TABLE XVII.

When the Planet Venus is used, and the Parallax is nearly equal to 30″

PARALLAX 30″.

*Ap. Alt.	Cor.	Log.	*Ap. Alt.	Cor.	Log.	*Ap. Alt.	Cor.	Log.	*Ap. Alt.	Cor.	Log.	*Ap. Alt.	Cor.	Log.
D M	M S		D M	M S		D M	M S		D M	M S		D M	M S	
5. 0	50.37	0.9801	10. 0	55.15	1.2702	13.15	56.31	1.3999	19. 0	57.44	1.5745	36.30	59.07	1.9151
10	50.53	0.9926	3	55.16	1.2724	20	56.32	1.4029	10	57.46	1.5789	37. 0	59.08	1.9225
20	51.08	1.0049	6	55.18	1.2746	25	56.34	1.4058	20	57.47	1.5832	30	59.10	1.9297
30	51.23	1.0170	9	55.19	1.2769	30	56.35	1.4087	30	57.49	1.5875	38. 0	59.11	1.9369
40	51.37	1.0288	12	55.21	1.2791	35	56.37	1.4116	40	57.50	1.5918	30	59.12	1.9440
50	51.50	1.0403	15	55.22	1.2813	40	56.38	1.4145	50	57.52	1.5960	39. 0	59.13	1.9511
6. 0	52.03	1.0516	10.18	55.24	1.2835	13.45	56.40	1.4174	20. 0	57.53	1.6002	39.30	59.14	1.9580
10	52.15	1.0627	21	55.25	1.2857	50	56.41	1.4203	10	57.54	1.6044	40. 0	59.15	1.9648
20	52.27	1.0735	24	55.26	1.2879	55	56.42	1.4231	20	57.56	1.6085	30	59.16	1.9716
30	52.38	1.0842	27	55.28	1.2900	14. 0	56.44	1.4259	30	57.57	1.6126	41. 0	59.17	1.9783
40	52.49	1.0947	30	55.29	1.2922	5	56.45	1.4287	40	57.58	1.6167	30	59.18	1.9849
50	52.59	1.1049	33	55.31	1.2944	10	56.46	1.4315	50	57.59	1.6207	42. 0	59.19	1.9914
7. 0	53.09	1.1149	10.36	55.32	1.2966	14.15	56.48	1.4343	21. 0	58.01	1.6247	42.30	59.20	1.9978
10	53.18	1.1248	39	55.33	1.2987	20	56.49	1.4371	10	58.02	1.6287	43. 0	59.21	2.0042
20	53.27	1.1345	42	55.35	1.3008	25	56.50	1.4399	20	58.03	1.6327	30	59.22	2.0105
30	53.36	1.1441	45	55.36	1.3029	30	56.52	1.4427	30	58.04	1.6366	44. 0	59.23	2.0167
35	53.40	1.1488	48	55.37	1.3050	35	56.53	1.4454	40	58.05	1.6405	30	59.24	2.0228
40	53.45	1.1534	51	55.39	1.3071	40	56.54	1.4481	50	58.07	1.6444	45. 0	59.24	2.0289
7.45	53.49	1.1579	10.54	55.40	1.3092	14.45	56.55	1.4508	22. 0	58.08	1.6483	46.	59.26	2.0408
48	53.51	1.1608	57	55.41	1.3113	50	56.57	1.4535	10	58.09	1.6522	47.	59.27	2.0524
51	53.53	1.1636	11. 0	55.43	1.3134	55	56.58	1.4562	20	58.10	1.6560	48.	59.29	2.0637
54	53.56	1.1663	3	55.44	1.3155	15. 0	56.59	1.4589	30	58.11	1.6598	49.	59.30	2.0747
57	53.58	1.1690	6	55.45	1.3176	5	57.00	1.4616	40	58.12	1.6636	50.	59.32	2.0855
8. 0	54.00	1.1717	9	55.46	1.3197	10	57.01	1.4643	50	58.13	1.6673	51.	59.33	2.0960
8. 3	54.02	1.1744	11.12	55.48	1.3217	15.15	57.02	1.4669	23. 0	58.14	1.6710	52.	59.34	2.1062
6	54.05	1.1771	15	55.49	1.3237	20	57.03	1.4695	10	58.15	1.6747	53.	59.35	2.1162
9	54.07	1.1798	18	55.50	1.3258	25	57.05	1.4721	20	58.16	1.6784	54.	59.36	2.1259
12	54.09	1.1824	21	55.51	1.3278	30	57.06	1.4747	30	58.17	1.6820	55.	59.37	2.1353
15	54.11	1.1851	24	55.53	1.3298	35	57.07	1.4773	40	58.18	1.6857	56.	59.38	2.1445
18	54.13	1.1877	27	55.54	1.3318	40	57.08	1.4799	50	58.19	1.6893	57.	59.39	2.1534
8.21	54.16	1.1903	11.30	55.55	1.3338	15.45	57.09	1.4824	24. 0	58.20	1.6929	58.	59.40	2.1621
24	54.18	1.1929	33	55.56	1.3358	50	57.10	1.4850	10	58.21	1.6965	59.	59.41	2.1705
27	54.20	1.1955	36	55.57	1.3378	55	57.11	1.4876	20	58.22	1.7000	60.	59.42	2.1787
30	54.22	1.1981	39	55.58	1.3398	16. 0	57.12	1.4901	30	58.23	1.7035	61.	59.43	2.1866
33	54.24	1.2007	42	55.59	1.3418	5	57.13	1.4926	40	58.24	1.7070	62.	59.44	2.1942
36	54.26	1.2032	45	56.01	1.3438	10	57.14	1.4951	50	58.25	1.7105	63.	59.45	2.2016
8.39	54.28	1.2057	11.48	56.02	1.3458	16.15	57.15	1.4976	25. 0	58.26	1.7140	64.	59.45	2.2087
42	54.30	1.2082	51	56.03	1.3478	20	57.16	1.5001	20	58.27	1.7208	65.	59.46	2.2156
45	54.32	1.2107	54	56.04	1.3498	25	57.17	1.5026	40	58.29	1.7276	66.	59.47	2.2222
48	54.34	1.2132	57	56.05	1.3517	30	57.18	1.5050	26. 0	58.31	1.7343	67.	59.48	2.2280
51	54.36	1.2157	12. 0	56.06	1.3536	35	57.19	1.5075	20	58.32	1.7410	68.	59.48	2.2347
54	54.38	1.2182	3	56.07	1.3555	40	57.20	1.5100	40	58.34	1.7476	69.	59.49	2.2405
8.57	54.39	1.2207	12. 6	56.08	1.3574	16.45	57.21	1.5124	27. 0	58.35	1.7541	70.	59.50	2.2461
9. 0	54.41	1.2232	9	56.09	1.3593	50	57.22	1.5148	20	58.37	1.7605	71.	59.50	2.2514
3	54.43	1.2257	12	56.10	1.3612	55	57.23	1.5172	40	58.38	1.7669	72.	59.51	2.2565
6	54.45	1.2281	15	56.11	1.3631	17. 0	57.24	1.5196	28. 0	58.40	1.7732	73.	59.51	2.2613
9	54.47	1.2305	18	56.12	1.3650	5	57.25	1.5220	20	58.41	1.7794	74.	59.52	2.2658
12	54.48	1.2329	21	56.13	1.3669	10	57.26	1.5244	40	58.43	1.7856	75.	59.52	2.2701
9.15	54.50	1.2353	12.24	56.14	1.3688	17.15	57.27	1.5268	29. 0	58.44	1.7917	76.	59.53	2.2741
18	54.52	1.2377	27	56.15	1.3707	20	57.28	1.5292	30	58.46	1.8007	77.	59.54	2.2778
21	54.54	1.2401	30	56.16	1.3725	25	57.29	1.5315	30. 0	58.48	1.8097	78.	59.54	2.2812
24	54.55	1.2425	33	56.17	1.3744	30	57.29	1.5338	30	58.50	1.8185	79.	59.55	2.2844
27	54.57	1.2449	36	56.18	1.3763	35	57.30	1.5362	31. 0	58.51	1.8272	80.	59.55	2.2873
30	54.59	1.2472	39	56.19	1.3782	40	57.31	1.5385	30	58.53	1.8357	81.	59.56	2.2899
9.33	55.00	1.2495	12.42	56.20	1.3800	17.45	57.32	1.5408	32. 0	58.54	1.8441	82.	59.56	2.2923
36	55.02	1.2518	45	56.21	1.3818	50	57.33	1.5431	30	58.56	1.8524	83.	59.57	2.2944
39	55.04	1.2541	48	56.22	1.3837	55	57.34	1.5454	33. 0	58.58	1.8606	84.	59.57	2.2962
42	55.05	1.2564	51	56.23	1.3855	18. 0	57.35	1.5477	30	58.59	1.8687	85.	59.58	2.2977
45	55.07	1.2587	54	56.24	1.3873	10	57.36	1.5523	34. 0	59.01	1.8767	86.	59.58	2.2990
48	55.09	1.2610	57	56.25	1.3891	20	57.38	1.5568	30	59.02	1.8846	87.	59.58	2.3000
9.51	55.10	1.2633	13. 0	56.26	1.3909	18.30	57.39	1.5613	35. 0	59.03	1.8924	88.	59.59	2.3007
54	55.12	1.2656	5	56.28	1.3939	40	57.41	1.5657	30	59.05	1.9000	89.	59.59	2.3011
57	55.13	1.2679	10	56.29	1.3969	50	57.43	1.5701	36. 0	59.06	1.9076	90.	60.00	2.3031

Digitized by Google

TABLE XVII.

When the Planet Venus is used, and the Parallax is nearly equal to 35″.

Parallax 35″.

*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.	*Ap. Alt. D M	Cor. M S	Log.
5. 0	50.42	0.9840	10. 0	55.20	1.2777	13.15	56.36	1.4101	19. 0	57.49	1.5899	36.30	59.11	1.9495
10	50.58	0.9966	3	55.21	1.2800	20	56.37	1.4131	10	57.50	1.5944	37. 0	59.12	1.9575
20	51.13	1.0090	6	55.23	1.2823	25	56.39	1.4161	20	57.52	1.5989	30	59.14	1.9654
30	51.28	1.0212	9	55.24	1.2846	30	56.40	1.4191	30	57.53	1.6033	38. 0	59.15	1.9732
40	51.42	1.0331	12	55.26	1.2869	35	56.42	1.4221	40	57.55	1.6077	30	59.16	1.9809
50	51.55	1.0447	15	55.27	1.2891	40	56.43	1.4251	50	57.56	1.6121	39. 0	59.17	1.9886
6. 0	52.08	1.0561	10.18	55.29	1.2913	13.45	56.44	1.4281	20. 0	57.57	1.6165	39.30	59.18	1.9961
10	52.20	1.0673	21	55.30	1.2936	50	56.46	1.4310	10	57.59	1.6208	40. 0	59.19	2.0036
20	52.32	1.0783	24	55.31	1.2958	55	56.47	1.4339	20	58.00	1.6251	30	59.20	2.0110
30	52.43	1.0891	27	55.33	1.2980	14. 0	56.49	1.43[illegible]	30	58.02	1.6294	41. 0	59.21	2.0183
40	52.54	1.0997	30	55.34	1.3002	5	56.50	1.4397	40	58.03	1.6336	30	59.22	2.0255
50	53.04	1.1100	33	55.36	1.3024	10	56.51	1.4426	50	58.04	1.6378	42. 0	59.23	2.0327
7. 0	53.14	1.1202	10.36	55.37	1.3046	14.15	56.53	1.4455	21. 0	58.05	1.6420	42.30	59.24	2.0398
10	53.23	1.1302	39	55.38	1.3068	20	56.54	1.4483	10	58.06	1.6462	43. 0	59.25	2.0468
20	53.32	1.1400	42	55.40	1.3090	25	56.55	1.4511	20	58.08	1.6503	30	59.26	2.0537
30	53.41	1.1497	45	55.41	1.3111	30	56.56	1.4540	30	58.09	1.6544	44. 0	59.26	2.0606
35	53.45	1.1545	48	55.42	1.3132	35	56.58	1.4568	40	58.10	1.6585	30	59.27	2.0674
40	53.49	1.1592	51	55.44	1.3154	40	56.59	1.4596	50	58.11	1.6626	45. 0	59.28	2.0741
7.45	53.53	1.1638	10.54	55.45	1.3176	14.45	57.00	1.4624	22. 0	58.12	1.6666	46.	59.29	2.0873
48	53.56	1.1667	57	55.46	1.3197	50	57.01	1.4652	10	58.13	1.6706	47.	59.31	2.1003
51	53.58	1.1695	11. 0	55.48	1.3218	55	57.02	1.4679	20	58.14	1.6746	48.	59.32	2.1129
54	54.01	1.1723	3	55.49	1.3239	15. 0	57.04	1.4706	30	58.15	1.6785	49.	59.33	2.125[illegible]
57	54.03	1.1751	6	55.50	1.3260	5	57.05	1.4734	40	58.17	1.6824	50.	59.35	2.137[illegible]
8. 0	54.05	1.1778	9	55.51	1.3281	10	57.06	1.4761	50	58.18	1.6863	51.	59.36	2.149[illegible]
8. 3	54.07	1.1805	11.12	55.53	1.3302	15.15	57.07	1.4788	23. 0	58.19	1.6902	52.	59.37	2.160[illegible]
6	54.10	1.1832	15	55.54	1.3323	20	57.08	1.4815	10	58.20	1.6941	53.	59.38	2.172[illegible]
9	54.12	1.1859	18	55.55	1.3344	25	57.09	1.4842	20	58.21	1.6980	54.	59.39	2.183[illegible]
12	54.14	1.1886	21	55.56	1.3365	30	57.10	1.4869	30	58.22	1.7018	55.	59.40	2.194[illegible]
15	54.16	1.1913	24	55.58	1.3386	35	57.12	1.4896	40	58.23	1.7056	56.	59.41	2.204[illegible]
18	54.18	1.1939	27	55.59	1.3406	40	57.13	1.4922	50	58.24	1.7094	57.	59.42	2.2148
8.21	54.21	1.1966	11.30	56.00	1.3426	15.45	57.14	1.4948	24. 0	58.25	1.7132	58.	59.43	2.2248
24	54.23	1.1993	33	56.01	1.3447	50	57.15	1.4975	10	58.26	1.7169	59.	59.44	2.2346
27	54.25	1.2019	36	56.02	1.3467	55	57.16	1.5001	20	58.27	1.7206	60.	59.45	2.2440
30	54.27	1.2045	39	56.03	1.3487	16. 0	57.17	1.5027	30	58.28	1.7243	61.	59.45	2.2532
33	54.29	1.2071	42	56.04	1.3507	5	57.18	1.5053	40	58.29	1.7280	62.	59.46	2.2621
36	54.31	1.2097	45	56.06	1.3527	10	57.19	1.5079	50	58.29	1.7317	63.	59.47	2.2708
8.39	54.33	1.2123	11.48	56.07	1.3547	16.15	57.20	1.5104	25. 0	58.30	1.7353	64.	59.48	2.2792
42	54.35	1.2148	51	56.08	1.3567	20	57.21	1.5130	20	58.32	1.7425	65.	59.48	2.2873
45	54.37	1.2173	54	56.09	1.3587	25	57.22	1.5156	40	58.34	1.7496	66.	59.49	2.2951
48	54.39	1.2199	57	56.10	1.3607	30	57.23	1.5181	26. 0	58.35	1.7567	67.	59.49	2.3026
51	54.41	1.2224	12. 0	56.11	1.3627	35	57.24	1.5206	20	58.37	1.7637	68.	59.50	2.3099
54	54.43	1.2249	3	56.12	1.3647	40	57.25	1.5231	40	58.38	1.7706	69.	59.51	2.3168
8.57	54.44	1.2275	12. 6	56.13	1.3667	16.45	57.26	1.5256	27. 0	58.40	1.7775	70.	59.51	2.3235
9. 0	54.46	1.2300	9	56.14	1.3686	50	57.27	1.5281	20	58.41	1.7843	71.	59.52	2.3299
3	54.48	1.2325	12	56.15	1.3706	55	57.28	1.5306	40	58.43	1.7910	72.	59.52	2.3359
6	54.50	1.2350	15	56.16	1.3725	17. 0	57.29	1.5331	28. 0	58.44	1.7977	73.	59.53	2.3417
9	54.52	1.2374	18	56.17	1.3745	5	57.30	1.5356	20	58.46	1.8043	74.	59.53	2.3471
12	54.53	1.2399	21	56.18	1.3764	10	57.31	1.5381	40	58.47	1.8108	75.	59.54	2.3523
9.15	54.55	1.2423	12.24	56.19	1.3783	17.15	57.32	1.5405	29. 0	58.48	1.8173	76.	59.55	2.3571
18	54.57	1.2448	27	56.20	1.3802	20	57.33	1.5430	30	58.50	1.8269	77.	59.55	2.3616
21	54.59	1.2472	30	56.21	1.3821	25	57.34	1.5454	30. 0	58.52	1.8364	78.	59.55	2.3658
24	55.00	1.2496	33	56.22	1.3840	30	57.34	1.5478	30	58.54	1.8457	79.	59.56	2.3697
27	55.02	1.2520	36	56.23	1.3859	35	57.35	1.5502	31. 0	58.55	1.8550	80.	59.56	2.3732
30	55.04	1.2544	39	56.24	1.3878	40	57.36	1.5526	30	58.57	1.8641	81.	59.57	2.3764
9.33	55.05	1.2568	12.42	56.25	1.3897	17.45	57.37	1.5550	32. 0	58.59	1.8732	82.	59.57	2.3793
36	55.07	1.2592	45	56.26	1.3916	50	57.38	1.5574	30	59.01	1.8821	83.	59.57	2.3819
39	55.09	1.2615	48	56.27	1.3935	55	57.39	1.5598	33. 0	59.02	1.8909	84.	59.58	2.3841
42	55.10	1.2639	51	56.28	1.3954	18. 0	57.39	1.5621	30	59.03	1.8996	85.	59.58	2.3859
45	55.12	1.2662	54	56.29	1.3973	10	57.41	1.5668	34. 0	59.05	1.9081	86.	59.58	2.3874
48	55.14	1.2685	57	56.30	1.3991	20	57.43	1.5715	30	59.06	1.9165	87.	59.59	2.3886
9.51	55.15	1.2708	13. 0	56.31	1.4009	18.30	57.44	1.5761	35. 0	59.08	1.9249	88.	59.59	2.3895
54	55.17	1.2731	5	56.33	1.4040	40	57.46	1.5807	30	59.09	1.9332	89.	59.59	2.3900
57	55.18	1.2754	10	56.34	1.4071	50	57.48	1.5853	36. 0	59.10	1.9414	90.	60.00	2.3903

Digitized by Google

TABLE XVIII.

When the Sun is used.

⊙Ap. Alt.	Cor.	Log.	⊙Ap. Alt.	Cor.	Log.	⊙Ap. Alt.	Cor.	Log.	⊙Ap. Alt.	Cor.	Log.	⊙Ap. Alt.	Cor.	Log.
D M	M S		D M	M S		D M	M S		D M	M S		D M	M S	
5. 0	50.16	0.9645	10. 0	54.54	1.2397	13.15	56.10	1.3592	19. 0	57.24	1.5149	36.30	58.50	1.7934
10	50.32	0.9766	3	54.55	1.2418	20	56.12	1.3619	10	57.25	1.5187	37. 0	58.51	1.7990
20	50.48	0.9885	6	54.57	1.2439	25	56.13	1.3645	20	57.27	1.5225	30	58.53	1.8045
30	51. 3	1.0000	9	54.58	1.2460	30	56.15	1.3672	30	57.28	1.5262	38. 0	58.54	1.8100
40	51.16	1.0113	12	55. 0	1.2481	35	56.16	1.3699	40	57.30	1.5299	30	58.55	1.8154
50	51.30	1.0223	15	55. 1	1.2501	40	56.17	1.3725	50	57.31	1.5336	39. 0	58.57	1.8206
6. 0	51.42	1.0330	10.18	55. 3	1.2522	13.45	56.19	1.3751	20. 0	57.33	1.5372	39.30	58.58	1.8257
10	51.55	1.0437	21	55. 4	1.2543	50	56.20	1.3777	10	57.34	1.5408	40. 0	58.59	1.8307
20	52. 6	1.0541	24	55. 6	1.2563	55	56.22	1.3803	20	57.35	1.5444	30	59. 0	1.8357
30	52.17	1.0643	27	55. 7	1.2583	14. 0	56.23	1.3828	30	57.37	1.5480	41. 0	59. 1	1.8406
40	52.28	1.0742	30	55. 8	1.2603	5	56.24	1.3853	40	57.38	1.5515	30	59. 2	1.8454
50	52.38	1.0840	33	55.10	1.2623	10	56.26	1.3878	50	57.39	1.5550	42. 0	59. 3	1.8500
7. 0	52.48	1.0935	10.36	55.11	1.2643	14.15	56.27	1.3904	21. 0	57.41	1.5585	42.30	59. 4	1.8546
10	52.57	1.1029	39	55.13	1.2663	20	56.28	1.3929	10	57.42	1.5619	43. 0	59. 5	1.8593
20	53. 6	1.1122	42	55.14	1.2683	25	56.30	1.3954	20	57.43	1.5653	30	59. 6	1.8638
30	53.15	1.1212	45	55.15	1.2702	30	56.31	1.3979	30	57.44	1.5686	44. 0	59. 7	1.8683
35	53.19	1.1257	48	55.17	1.2722	35	56.32	1.4004	40	57.46	1.5719	30	59. 8	1.8726
40	53.23	1.1301	51	55.18	1.2742	40	56.33	1.4029	50	57.47	1.5752	45. 0	59. 9	1.8768
7.45	53.27	1.1345	10.54	55.19	1.2761	14.45	56.35	1.4053	22. 0	57.48	1.5784	46.	59.11	1.8848
48	53.30	1.1371	57	55.20	1.2780	50	56.36	1.4077	10	57.49	1.5817	47.	59.13	1.8928
51	53.32	1.1397	11. 0	55.22	1.2799	55	56.37	1.4101	20	57.50	1.5849	48.	59.15	1.9004
54	53.35	1.1423	3	55.23	1.2818	15. 0	56.38	1.4125	30	57.51	1.5881	49.	59.16	1.9081
57	53.37	1.1448	6	55.24	1.2837	5	56.39	1.4149	40	57.52	1.5913	50.	59.18	1.9154
8. 0	53.39	1.1474	9	55.26	1.2856	10	56.41	1.4173	50	57.53	1.5945	51.	59.19	1.9225
8. 3	53.41	1.1499	11.12	55.27	1.2875	15.15	56.42	1.4197	23. 0	57.54	1.5976	52.	59.21	1.9294
6	53.44	1.1524	15	55.28	1.2894	20	56.43	1.4221	10	57.56	1.6008	53.	59.22	1.9362
9	53.46	1.1550	18	55.29	1.2913	25	56.44	1.4244	20	57.57	1.6039	54.	59.24	1.9424
12	53.48	1.1575	21	55.30	1.2932	30	56.45	1.4267	30	57.58	1.6070	55.	59.25	1.9484
15	53.50	1.1599	24	55.32	1.2951	35	56.46	1.4290	40	57.59	1.6101	56.	59.26	1.9544
18	53.52	1.1624	27	55.33	1.2970	40	56.47	1.4313	50	58. 0	1.6131	57.	59.28	1.9602
8.21	53.55	1.1649	11.30	55.34	1.2988	15.45	56.49	1.4336	24. 0	58. 1	1.6161	58.	59.29	1.9658
24	53.57	1.1673	33	55.35	1.3007	50	56.50	1.4359	10	58. 2	1.6191	59.	59.30	1.9715
27	53.59	1.1698	36	55.36	1.3025	55	56.51	1.4382	20	58. 3	1.6221	60.	59.31	1.9761
30	54. 1	1.1722	39	55.38	1.3043	16. 0	56.52	1.4404	30	58. 3	1.6250	61.	59.33	1.9807
33	54. 3	1.1746	42	55.39	1.3061	5	56.53	1.4427	40	58. 4	1.6279	62.	59.34	1.9854
36	54. 5	1.1770	45	55.40	1.3079	10	56.54	1.4449	50	58. 5	1.6308	63.	59.35	1.9901
8.39	54. 7	1.1794	11.48	55.41	1.3097	16.15	56.55	1.4471	25. 0	58. 6	1.6336	64.	59.36	1.9946
42	54. 9	1.1818	51	55.42	1.3115	20	56.56	1.4493	20	58. 8	1.6393	65.	59.37	1.9986
45	54.11	1.1841	54	55.43	1.3133	25	56.57	1.4515	40	58.10	1.6449	66.	59.38	2.0025
48	54.13	1.1865	57	55.44	1.3151	30	56.58	1.4537	26. 0	58.11	1.6505	67.	59.39	2.0064
51	54.15	1.1888	12. 0	55.45	1.3169	35	56.59	1.4559	20	58.13	1.6559	68.	59.40	2.0100
54	54.16	1.1912	3	55.46	1.3187	40	57. 0	1.4581	40	58.15	1.6612	69.	59.41	2.0136
8.57	54.18	1.1935	12. 6	55.48	1.3205	16.45	57. 1	1.4602	27. 0	58.16	1.6665	70.	59.42	2.0173
9. 0	54.20	1.1958	9	55.49	1.3223	50	57. 2	1.4624	20	58.18	1.6718	71.	59.43	2.0208
3	54.22	1.1981	12	55.50	1.3240	55	57. 3	1.4646	40	58.19	1.6771	72.	59.44	2.0238
6	54.24	1.2004	15	55.51	1.3257	17. 0	57. 4	1.4667	28. 0	58.21	1.6824	73.	59.45	2.0268
9	54.26	1.2026	18	55.52	1.3275	5	57. 5	1.4688	20	58.22	1.6874	74.	59.46	2.0296
12	54.27	1.2049	21	55.53	1.3292	10	57. 6	1.4709	40	58.24	1.6923	75.	59.47	2.0322
9.15	54.29	1.2071	12.24	55.54	1.3309	17.15	57. 6	1.4730	29. 0	58.25	1.6972	76.	59.48	2.0343
18	54.31	1.2094	27	55.55	1.3326	20	57. 7	1.4751	30	58.27	1.7046	77.	59.49	2.0363
21	54.33	1.2116	30	55.56	1.3343	25	57. 8	1.4772	30. 0	58.29	1.7117	78.	59.50	2.0382
24	54.34	1.2139	33	55.57	1.3360	30	57. 9	1.4793	30	58.31	1.7187	79.	59.51	2.0400
27	54.36	1.2161	36	55.58	1.3377	35	57.10	1.4814	31. 0	58.33	1.7255	80.	59.52	2.0417
30	54.38	1.2183	39	55.59	1.3394	40	57.11	1.4835	30	58.35	1.7321	81.	59.52	2.0432
9.33	54.39	1.2205	12.42	56. 0	1.3411	17.45	57.12	1.4855	32. 0	58.36	1.7387	82.	59.53	2.0446
36	54.41	1.2227	45	56. 1	1.3427	50	57.13	1.4876	30	58.38	1.7454	83.	59.54	2.0450
39	54.43	1.2248	48	56. 2	1.3444	55	57.14	1.4896	33. 0	58.40	1.7520	84.	59.55	2.0453
42	54.44	1.2270	51	56. 3	1.3461	18. 0	57.14	1.4916	30	58.41	1.7582	85.	59.56	2.0456
45	54.46	1.2291	54	56. 4	1.3478	10	57.16	1.4956	34. 0	58.43	1.7643	86.	59.57	2.0458
48	54.48	1.2313	57	56. 5	1.3494	20	57.18	1.4995	30	58.44	1.7702	87.	59.57	2.0460
9.51	54.49	1.2334	13. 0	56. 6	1.3510	18.30	57.19	1.5034	35. 0	58.46	1.7762	88.	59.58	2.0461
54	54.51	1.2355	5	56. 7	1.3538	40	57.21	1.5073	30	58.47	1.7821	89.	59.59	2.0462
57	54.52	1.2376	10	56. 9	1.3565	50	57.22	1.5111	36. 0	58.49	1.7878	90.	60. 0	2.0462

Digitized by Google

TABLE XIX. Correction.

App. Alt. D's cen.		D's Horizontal Parallax.							
D.	M.	54′	55′	56′	57′	58′	59′	60′	61′
5	0	14.35	13.35	12.35	11.36	10.36	9.36	8.36	7.37
	10	14.20	13.20	12.20	11.20	10.21	9.21	8.21	7.21
	20	14. 5	13. 5	12. 6	11. 6	10. 6	9. 6	8. 7	7. 7
	30	13.51	12.52	11.52	10.52	9.52	8.53	7.53	6.53
	40	13.38	12.39	11.39	10.39	9.39	8.40	7.40	6.40
	50	13.26	12.26	11.27	10.27	9.27	8.27	7.28	6.28
6	0	13.17	12.18	11.18	10.18	9.19	8.19	7.19	6.20
	10	13. 6	12. 7	11. 7	10. 7	9. 8	8. 8	7. 8	6. 8
	20	12.55	11.56	10.56	9.57	8.57	7.57	6.58	5.58
	30	12.45	11.46	10.46	9.46	8.47	7.47	6.48	5.48
	40	12.36	11.36	10.37	9.37	8.37	7.38	6.38	5.39
	50	12.27	11.27	10.28	9.28	8.28	7.29	6.29	5.30
7	0	12.18	11.19	10.19	9.19	8.20	7.20	6.21	5.21

TABLE A. Proportional part for Seconds of Parallax. Add.

S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
0	59	58	57	56	55	54	53	52	51	50
10	49	48	47	46	45	44	43	42	41	40
20	39	38	37	36	35	34	33	32	31	30
30	29	28	27	26	25	24	23	22	21	20
40	19	18	17	16	15	14	13	12	11	10
50	9	8	7	6	5	4	3	2	1	0
0	59	58	57	56	55	54	53	52	51	50
10	49	48	47	46	45	44	43	42	41	40
20	39	38	37	36	35	34	33	32	31	30
30	29	28	27	26	25	24	23	22	21	20
40	19	18	17	16	15	14	13	12	11	10
50	9	8	7	6	5	4	3	2	1	0

TABLE B. For Min. of Alt. Add.

M.	S.
0	12
1	11
2	9
3	8
4	7
5	6
6	4
7	3
8	2
9	0
0	9
1	8
2	7
3	6
4	5
5	4
6	3
7	2
8	1
9	0

TABLE XIX. Logarithms.

D's Hor. Parallax.		Apparent Altitude of D's Centre.												
M.	S.	5° 0′	5° 10′	5° 20′	5° 30′	5° 40′	5° 50′	6° 0′	6° 10′	6° 20′	6° 30′	6° 40′	6° 50′	7° 0′
54	0	3084	3058	3033	3009	2987	2966	2946	2926	2908	2891	2874	2859	2844
	10	3068	3041	3016	2993	2971	2950	2930	2911	2892	2875	2859	2843	2828
	20	3051	3025	3000	2977	2955	2934	2914	2895	2877	2860	2843	2827	2813
	30	3035	3009	2984	2961	2939	2918	2898	2879	2861	2844	2828	2812	2797
	40	3019	2993	2968	2945	2923	2902	2883	2864	2846	2828	2812	2797	2782
	50	3003	2977	2952	2929	2907	2887	2867	2848	2830	2813	2797	2781	2767
55	0	2987	2961	2936	2913	2891	2871	2851	2833	2815	2798	2781	2766	2751
	10	2971	2945	2921	2898	2876	2855	2836	2817	2799	2782	2766	2751	2736
	20	2955	2929	2905	2882	2860	2840	2820	2802	2784	2767	2751	2736	2721
	30	2939	2913	2889	2866	2845	2824	2805	2786	2769	2752	2736	2720	2706
	40	2923	2897	2873	2851	2829	2809	2790	2771	2753	2737	2721	2705	2691
	50	2907	2882	2858	2835	2814	2793	2774	2756	2738	2721	2706	2690	2676
56	0	2891	2866	2842	2820	2798	2778	2759	2741	2723	2706	2690	2675	2661
	10	2876	2851	2827	2804	2783	2763	2744	2725	2708	2691	2676	2660	2646
	20	2860	2835	2811	2789	2768	2748	2729	2710	2693	2676	2661	2646	2631
	30	2844	2820	2796	2774	2752	2732	2714	2695	2678	2661	2646	2631	2617
	40	2829	2804	2780	2758	2737	2717	2698	2680	2663	2647	2631	2616	2602
	50	2813	2789	2765	2743	2722	2702	2683	2665	2648	2632	2616	2601	2587
57	0	2798	2773	2750	2728	2707	2687	2669	2650	2633	2617	2601	2587	2573
	10	2783	2758	2735	2713	2692	2672	2654	2636	2618	2602	2587	2572	2558
	20	2767	2743	2720	2698	2677	2657	2639	2621	2604	2588	2572	2557	2543
	30	2752	2728	2705	2683	2662	2642	2624	2606	2589	2573	2558	2543	2529
	40	2737	2713	2690	2668	2647	2628	2609	2591	2574	2558	2543	2528	2515
	50	2722	2698	2675	2653	2632	2613	2595	2577	2560	2544	2529	2514	2500
58	0	2707	2683	2660	2638	2618	2598	2580	2562	2545	2529	2514	2500	2486
	10	2692	2668	2645	2623	2603	2584	2565	2548	2531	2515	2500	2485	2472
	20	2677	2653	2630	2609	2588	2569	2551	2533	2516	2501	2485	2471	2457
	30	2662	2638	2615	2594	2574	2554	2536	2519	2502	2486	2471	2457	2443
	40	2647	2623	2601	2579	2559	2540	2522	2504	2488	2472	2457	2443	2429
	50	2632	2608	2586	2565	2544	2525	2507	2490	2473	2458	2443	2428	2415
59	0	2617	2594	2571	2550	2530	2511	2493	2476	2459	2444	2429	2414	2401
	10	2603	2579	2557	2536	2516	2497	2479	2461	2445	2429	2415	2400	2387
	20	2588	2565	2542	2521	2501	2482	2465	2447	2431	2415	2400	2386	2373
	30	2573	2550	2528	2507	2487	2468	2450	2433	2417	2401	2386	2372	2359
	40	2559	2535	2513	2492	2473	2454	2436	2419	2403	2387	2373	2358	2345
	50	2544	2521	2499	2478	2458	2440	2422	2405	2389	2373	2359	2345	2331
60	0	2530	2507	2485	2464	2444	2425	2408	2391	2375	2359	2345	2331	2317
	10	2515	2492	2470	2450	2430	2411	2394	2377	2361	2345	2331	2317	2304
	20	2501	2478	2456	2435	2416	2397	2380	2363	2347	2332	2317	2303	2290
	30	2487	2464	2442	2421	2402	2383	2366	2349	2333	2318	2303	2290	2276
	40	2472	2450	2428	2407	2388	2369	2352	2335	2319	2304	2290	2276	2263
	50	2458	2435	2414	2393	2374	2356	2339	2321	2306	2290	2276	2262	2249
61	0	2444	2421	2400	2379	2360	2342	2325	2308	2292	2277	2262	2249	2236
	10	2430	2407	2386	2365	2346	2328	2311	2294	2278	2263	2249	2235	2222
	20	2416	2393	2372	2351	2332	2314	2297	2280	2265	2250	2235	2222	2209
	30	2402	2379	2358	2338	2318	2300	2283	2267	2251	2236	2222	2208	2195

TABLE C. Cor. for Sec. of Par. Add.

Sec.	Cor.
0	14
1	13
2	11
3	9
4	8
5	6
6	5
7	3
8	1
9	0
Sec.	**Cor.**
0	14
1	13
2	11
3	10
4	8
5	7
6	5
7	4
8	2
9	1
Sec.	**Cor.**
0	14
1	13
2	11
3	10
4	8
5	7
6	5
7	4
8	2
9	1
Sec.	**Cor.**
0	14
1	13
2	11
3	10
4	8
5	7
6	6
7	4
8	3
9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt. ☾'s cen.		☽'s Horizontal Parallax.								Table A. Proportional part for Seconds of Parallax. Add.										
D.	M.	54′	55′	56′	57′	58′	59′	60′	61′	S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
7	0	12.21	11.22	10.22	9.22	8.23	7.23	6.24	5.24	0	59	58	57	56	55	54	53	52	51	50
	10	12.13	11.13	10.14	9.14	8.15	7.15	6.16	5.16	10	49	48	47	46	45	44	43	42	41	40
	20	12. 5	11. 5	10. 6	9. 6	8. 7	7. 7	6. 8	5. 8	20	39	38	37	36	35	34	33	32	31	30
	30	11.58	10.58	9.59	8.59	8. 0	7. 0	6. 1	5. 1	30	29	28	27	26	25	24	23	22	21	20
	40	11.50	10.51	9.51	8.52	7.53	6.53	5.54	4.54	40	19	18	17	16	15	14	13	12	11	10
										50	9	8	7	6	5	4	3	2	1	0

Table B. For Min. of Alt. Add.

M.	S.
0	6
1	5
2	5
3	4
4	3
5	2
6	2
7	1
8	0
9	0

TABLE XIX. Logarithms.

☽'s Hor. Parallax.		Apparent Altitude of ☽'s centre.											
M.	S.	7° 3′	7° 6′	7° 9′	7° 12′	7° 15′	7° 18′	7° 21′	7° 24′	7° 27′	7° 30′	7° 33′	7° 36′
54	0	2841	2836	2831	2827	2823	2819	2815	2811	2807	2803	2799	2795
	10	2825	2821	2816	2812	2808	2804	2800	2796	2791	2787	2783	2780
	20	2810	2805	2800	2796	2792	2788	2784	2780	2776	2772	2768	2765
	30	2794	2790	2785	2781	2777	2773	2769	2765	2761	2757	2753	2749
	40	2777	2774	2770	2766	2762	2758	2754	2750	2746	2742	2738	2734
	50	276[illegible]	2759	2755	2751	2747	2743	2739	2735	2731	2727	2723	2719
55	0	2748	2744	2739	2735	2731	2727	2723	2719	2716	2712	2708	2704
	10	2733	2729	2724	2720	2716	2712	2708	2704	2700	2696	2692	2689
	20	2718	2714	2709	2705	2701	2697	2693	2689	2685	2681	2677	2674
	30	2703	2699	2694	2690	2686	2682	2678	2674	2671	2667	2663	2659
	40	2688	2684	2679	2675	2671	2667	2663	2659	2656	2652	2648	2644
	50	2673	2669	2664	2660	2656	2653	2649	2645	2641	2637	2633	2630
56	0	2658	2654	2649	2645	2641	2638	2634	2630	2626	2622	2618	2615
	10	2643	2639	2635	2631	2627	2623	2619	2615	2611	2607	2603	2600
	20	2628	2624	2620	2616	2612	2608	2604	2600	2597	2593	2589	2586
	30	2614	2610	2606	2602	2598	2594	2590	2586	2582	2578	2574	2571
	40	2599	2595	2591	2587	2583	2579	2575	2571	2567	2563	2559	2556
	50	2584	2580	2576	2572	2568	2564	2560	2556	2553	2549	2545	2542
57	0	2570	2566	2562	2558	2554	2550	2546	2542	2538	2534	2530	2527
	10	2555	2551	2547	2543	2539	2535	2531	2527	2524	2520	2516	2513
	20	2540	2536	2532	2528	2524	2521	2517	2513	2510	2506	2502	2499
	30	2526	2522	2518	2514	2510	2506	2503	2499	2495	2491	2487	2484
	40	2512	2508	2504	2500	2496	2492	2488	2484	2481	2477	2473	2470
	50	2497	2493	2489	2485	2481	2478	2474	2470	2467	2463	2459	2456
58	0	2483	2479	2475	2471	2467	2463	2460	2456	2452	2448	2444	2441
	10	2469	2465	2461	2457	2453	2449	2445	2441	2438	2434	2430	2427
	20	2454	2450	2446	2442	2438	2435	2431	2427	2424	2420	2416	2413
	30	2440	2436	2432	2428	2424	2421	2417	2413	2410	2406	2402	2399
	40	2426	2422	2418	2414	2410	2407	2403	2399	2396	2392	2388	2385
	50	2412	2408	2404	2400	2396	2393	2389	2385	2382	2378	2374	2371
59	0	2398	2394	2390	2386	2382	2379	2375	2371	2368	2364	2360	2357
	10	2384	2380	2376	2372	2368	2365	2361	2357	2354	2350	2346	2343
	20	2370	2366	2362	2358	2354	2351	2347	2343	2340	2336	2332	2329
	30	2356	2352	2348	2345	2341	2337	2334	2330	2327	2323	2319	2316
	40	2342	2338	2334	2331	2327	2323	2320	2316	2313	2309	2305	2302
	50	2328	2324	2320	2317	2313	2309	2306	2302	2299	2295	2291	2288
60	0	2314	2311	2307	2303	2299	2296	2292	2289	2286	2282	2278	2275
	10	2301	2297	2293	2290	2286	2282	2279	2275	2272	2268	2264	2261
	20	2287	2283	2279	2276	2272	2268	2265	2261	2258	2254	2250	2247
	30	2273	2270	2266	2262	2258	2255	2251	2248	2245	2241	2237	2234
	40	2260	2256	2252	2249	2245	2241	2238	2234	2231	2227	2223	2220
	50	2246	2243	2239	2235	2231	2228	2224	2221	2218	2214	2210	2207
61	0	2233	2229	2225	2222	2218	2214	2211	2207	2204	2200	2196	2193
	10	2219	2216	2212	2209	2205	2201	2198	2194	2191	2187	2183	2180
	20	2206	2202	2198	219[illegible]	2191	2187	2184	2181	2178	2174	2170	2167
	30	2192	2189	2165	2182	2178	2174	2171	2167	2164	2160	2157	2154

Table C. Correction for Seconds of Parallax. Add.

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	4
7	3
8	1
9	0

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	4
7	3
8	1
9	0

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	5
7	3
8	2
9	1

Sec.	Cor.
0	13
1	12
2	10
3	9
4	8
5	6
6	5
7	4
8	2
9	1

Digitized by Google

TABLE XIX.

Correction

App. Alt. D's cen.		D's Horizontal Parallax.								Table A. Proportional part for Seconds of Parallax. Add.										
D.	M.	54′	55′	56′	57′	58′	59′	60′	61′	S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
7	30	11.58	10.58	9.59	8.59	8. 0	7. 0	6. 1	5. 1	0	59	58	57	56	55	54	53	52	51	50
	40	11.50	10.51	9.51	8.52	7.53	6.53	5.54	4.54	10	49	48	47	46	45	44	43	42	41	40
	50	11.44	10.44	9.45	8.45	7.46	6.46	5.47	4.47	20	39	38	37	36	35	34	33	32	31	30
8	0	11.37	10.38	9.38	8.39	7.40	6.40	5.41	4.41	30	29	28	27	26	25	24	23	22	21	20
	10	11.31	10.32	9.32	8.33	7.33	6.34	5.35	4.35	40	19	18	17	16	15	14	13	12	11	10
	20	11.25	10.26	9.26	8.27	7.28	6.28	5.29	4.30	50	9	8	7	6	5	4	3	2	1	0

Table B
For Min of Alt.
Add.

M.	S.
1	6
2	5
3	5
4	4
5	3
6	2
7	2
8	1
9	0
	0

TABLE XIX. Logarithms.

D's Hor. Parallax.		Apparent Altitude of D's centre.											
M.	S.	7° 39′	7° 42′	7° 45′	7° 48′	7° 51′	7° 54′	7° 57′	8° 0′	8° 3′	8° 6′	8° 9′	8° 12′
54	0	2791	2787	2783	2780	2777	2774	2770	2766	2762	2759	2756	2753
	10	2776	2772	2768	2765	2762	2759	2755	2751	2747	2744	2741	2738
	20	2761	2757	2753	2750	2747	2743	2739	2736	2732	2729	2726	2723
	30	2745	2741	2737	2734	2731	2727	2724	2721	2717	2714	2711	2708
	40	2730	2726	2722	2719	2716	2712	2709	2706	2702	2699	2696	2693
	50	2715	2711	2707	2704	2701	2697	2694	2691	2687	2684	2681	2678
55	0	2700	2696	2692	2689	2686	2682	2679	2676	2672	2669	2666	2663
	10	2685	2681	2677	2674	2671	2667	2664	2661	2657	2654	2651	2648
	20	2670	2666	2662	2659	2656	2652	2649	2646	2642	2639	2636	2633
	30	2655	2651	2647	2644	2641	2637	2634	2631	2627	2624	2621	2618
	40	2640	2637	2633	2630	2627	2623	2619	2616	2612	2609	2606	2603
	50	2626	2622	2618	2615	2612	2608	2605	2602	2598	2595	2592	2589
56	0	2611	2607	2603	2600	2597	2593	2590	2587	2583	2580	2577	2574
	10	2596	2592	2589	2586	2583	2579	2575	2572	2569	2566	2563	2560
	20	2582	2578	2574	2571	2568	2564	2561	2558	2554	2551	2548	2545
	30	2567	2563	2559	2556	2553	2549	2546	2543	2540	2537	2534	2531
	40	2552	2548	2545	2542	2539	2535	2532	2529	2525	2522	2519	2516
	50	2538	2534	2530	2527	2524	2520	2517	2514	2511	2508	2505	2502
57	0	2523	2519	2516	2513	2510	2506	2503	2500	2496	2493	2490	2487
	10	2509	2505	2502	2499	2496	2492	2489	2486	2482	2479	2476	2473
	20	2495	2491	2487	2484	2481	2477	2474	2471	2468	2465	2462	2459
	30	2480	2476	2473	2470	2467	2463	2460	2457	2454	2451	2448	2445
	40	2466	2462	2459	2456	2453	2449	2446	2443	2440	2437	2434	2431
	50	2452	2448	2445	2442	2439	2435	2432	2429	2425	2422	2419	2416
58	0	2438	2434	2431	2428	2425	2421	2418	2415	2411	2408	2405	2402
	10	2424	2420	2416	2413	2410	2407	2404	2401	2397	2394	2391	2388
	20	2410	2406	2402	2399	2396	2393	2390	2387	2383	2380	2377	2374
	30	2396	2392	2388	2385	2382	2379	2376	2373	2369	2366	2363	2360
	40	2382	2378	2375	2372	2369	2365	2362	2359	2356	2353	2350	2347
	50	2368	2364	2361	2358	2355	2351	2348	2345	2342	2339	2336	2333
59	0	2354	2350	2347	2344	2341	2337	2334	2331	2328	2325	2322	2319
	10	2340	2336	2333	2330	2327	2323	2320	2317	2314	2311	2308	2305
	20	2326	2322	2319	2316	2313	2310	2307	2304	2301	2298	2295	2292
	30	2312	2308	2305	2302	2299	2296	2293	2290	2287	2284	2281	2278
	40	2299	2295	2292	2289	2286	2282	2279	2276	2273	2270	2267	2264
	50	2285	2281	2278	2275	2272	2269	2266	2263	2260	2257	2254	2251
60	0	2271	2268	2265	2262	2259	2255	2252	2249	2246	2243	2240	2237
	10	2258	2254	2251	2248	2245	2242	2239	2236	2233	2230	2227	2224
	20	2244	2240	2237	2234	2231	2228	2225	2222	2219	2216	2213	2210
	30	2231	2227	2224	2221	2218	2215	2212	2209	2206	2203	2200	2197
	40	2217	2214	2211	2208	2205	2201	2198	2195	2192	2189	2186	2183
	50	2204	2200	2197	2194	2191	2188	2185	2182	2179	2176	2173	2170
61	0	2190	2187	2184	2181	2178	2175	2172	2169	2166	2163	2160	2157
	10	2177	2174	2171	2168	2165	2161	2158	2155	2152	2149	2147	2144
	20	2164	2160	2157	2154	2151	2148	2145	2142	2139	2136	2133	2130
	30	2151	214[illegible]	2144	2141	2138	2135	2132	2129	2126	2123	2120	2117

Table C.
Correction for Seconds of Parallax.
Add.

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	4
7	3
8	1
9	0

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	4
7	3
8	1
9	0

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	5
7	3
8	2
9	1

Sec.	Cor.
0	13
1	12
2	10
3	9
4	8
5	6
6	5
7	4
8	2
9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt. ☽'s cen. D.	M.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	TABLE A. Proportional part for Seconds of Parallax. Add. S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
8	10	11.33	10.34	9.34	8.35	7.35	6.36	5.37	4.37	0	58	57	56	55	54	53	52	51	50	49
	20	11.27	10.28	9.28	8.29	7.30	6.30	5.31	4.32	10	48	47	46	45	44	43	42	41	40	39
	30	11.22	10.22	9.23	8.24	7.24	6.25	5.25	4.26	20	38	37	36	35	34	33	32	31	30	29
	40	11.16	10.17	9.18	8.18	7.19	6.20	5.20	4.21	30	28	27	26	25	24	23	22	21	20	19
	50	11.11	10.12	9.13	8.13	7.14	6.15	5.15	4.16	40	18	17	16	15	14	14	13	12	11	10
										50	9	8	7	6	5	4	3	2	1	0

TABLE B. For Min of Alt. Add.

M.	S.
0	5
1	4
2	4
3	3
4	3
5	2
6	2
7	1
8	1
9	0

TABLE XIX. Logarithms.

☽'s Hor. Parallax. M.	S.	Apparent Altitude of ☽'s centre. 8° 15′	8° 18′	8° 21′	8° 24′	8° 27′	8° 30′	8° 33′	8° 36′	8° 39′	8° 42′	8° 45′	8° 48′
54	0	2749	2746	2743	2740	2737	2734	2731	2728	2725	2722	2719	2716
	10	2734	2731	2728	2725	2722	2719	2716	2713	2710	2707	2704	2701
	20	2719	2716	2713	2710	2707	2704	2701	2698	2695	2692	2689	2686
	30	2704	2701	2698	2695	2692	2689	2686	2683	2680	2677	2674	2671
	40	2689	2686	2683	2680	2677	2674	2671	2668	2665	2662	2659	2656
	50	2675	2671	2668	2665	2662	2659	2656	2653	2650	2647	2644	2641
55	0	2659	2656	2653	2650	2647	2644	2641	2638	2635	2632	2629	2627
	10	2644	2641	2638	2635	2632	2629	2626	2623	2620	2617	2614	2612
	20	2629	2626	2623	2620	2617	2614	2611	2609	2606	2603	2600	2597
	30	2615	2612	2609	2606	2603	2600	2597	2594	2591	2588	2585	2583
	40	2600	2597	2594	2591	2588	2585	2582	2579	2576	2573	2570	2568
	50	2586	2582	2579	2576	2573	2570	2567	2564	2562	2559	2556	2553
56	0	2571	2568	2565	2562	2559	2556	2553	2550	2547	2544	2541	2539
	10	2556	2553	2550	2547	2544	2541	2538	2535	2533	2530	2527	2524
	20	2542	2539	2536	2533	2530	2527	2524	2521	2518	2515	2512	2510
	30	2527	2524	2521	2518	2515	2512	2509	2506	2504	2501	2498	2496
	40	2513	2510	2507	2504	2501	2498	2495	2492	2490	2487	2484	2481
	50	2499	2496	2493	2490	2487	2484	2481	2478	2475	2472	2469	2467
57	0	2484	2481	2478	2475	2472	2469	2466	2463	2461	2458	2455	2453
	10	2470	2467	2464	2461	2458	2455	2452	2449	2447	2444	2441	2439
	20	2456	2453	2450	2447	2444	2441	2438	2435	2433	2430	2427	2425
	30	2442	2439	2436	2433	2430	2427	2424	2421	2419	2416	2413	2411
	40	2427	2424	2421	2418	2416	2413	2410	2407	2405	2402	2399	2397
	50	2413	2410	2407	2404	2402	2399	2396	2393	2391	2388	2385	2383
58	0	2399	2396	2393	2390	2388	2385	2382	2379	2377	2374	2371	2369
	10	2385	2382	2379	2376	2374	2371	2368	2365	2363	2360	2357	2355
	20	2371	2368	2365	2362	2360	2357	2354	2351	2349	2346	2343	2341
	30	2357	2355	2352	2349	2346	2343	2340	2337	2335	2332	2329	2327
	40	2344	2341	2338	2335	2332	2329	2326	2323	2321	2318	2315	2313
	50	2330	2327	2324	2321	2318	2315	2312	2309	2307	2304	2302	2300
59	0	2316	2313	2310	2307	2305	2302	2299	2296	2294	2291	2289	2286
	10	2302	2299	2296	2293	2291	2288	2285	2282	2280	2277	2275	2272
	20	2289	2286	2283	2280	2277	2274	2271	2268	2266	2263	2261	2259
	30	2275	2272	2269	2266	2264	2261	2258	2255	2253	2250	2248	2245
	40	2261	2259	2256	2253	2250	2247	2244	2241	2239	2236	2234	2232
	50	2248	2245	2242	2239	2237	2234	2231	2228	2226	2223	2221	2218
60	0	2234	2232	2229	2216	2223	2220	2217	2214	2212	2209	2207	2205
	10	2221	2218	2215	2212	2209	2207	2204	2201	2199	2196	2194	2191
	20	2207	2205	2202	2199	2196	2193	2190	2188	2186	2183	2181	2178
	30	2194	2191	2188	2185	2183	2180	2177	2175	72	2169	2167	2165
	40	2180	2178	2175	2172	2170	2167	2164	2162	2159	2156	2154	2152
	50	2167	2165	2162	2159	2157	2154	2151	2149	2146	2143	2141	2138
61	0	2154	2151	2148	2145	2143	2140	2137	2135	2133	2130	2128	2125
	10	2141	2138	2135	2132	2130	2127	2124	2122	2119	2116	2114	2112
	20	2127	2125	2122	2119	2117	2114	2111	2109	2106	2103	2101	2099
	30	2114	2112	2109	2106	2104	2101	2098	2096	2093	2090	2088	2086

TABLE C. Correction for Seconds of Parallax. Add.

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	4
7	3
8	1
9	0

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	4
7	3
8	1
9	0

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	5
7	3
8	2
9	1

Sec.	Cor.
0	13
1	12
2	10
3	9
4	8
5	6
6	5
7	4
8	2
9	[illegible]

Digitized by Google

TABLE XIX

Correction

App. Alt. ☽'s cen. D.	M.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′
8	50	11.12	10.13	9.14	8.14	7.15	6.16	5.16	4.17
9	0	11. 7	10. 8	9. 9	8.10	7.10	6.11	5.12	4.13
	10	11. 3	10. 4	9. 4	8. 5	7. 6	6. 7	5. 7	4. 8
	20	10.59	9.59	9. 0	8. 1	7. 2	6. 2	5. 3	4. 4
	30	10.54	9.55	8.56	7.57	6.58	5.58	4.59	4. 0

Table A. Proportional part for Seconds of Parallax. Add.

S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
0	58	57	56	55	54	53	52	51	50	49
10	48	47	46	45	44	43	42	41	40	39
20	38	37	36	35	34	33	32	31	30	29
30	28	27	26	25	24	23	22	22	21	20
40	19	18	17	16	15	14	13	12	11	10
50	9	8	7	6	5	4	3	2	1	0

Table B. For Min. of Alt. Add.

M.	S.
0	4
1	4
2	3
3	3
4	2
5	2
6	2
7	1
8	1
9	0

TABLE XIX. Logarithms.

Apparent Altitude of ☽'s centre.

☽'s Hor. Parallax. M.	S.	8° 51′	8° 54′	8° 57′	9° 0′	9° 3′	9° 6′	9° 9′	9° 12′	9° 15′	9° 18′	9° 21′	9° 24′	9° 27′
54	0	2713	2710	2708	2705	2702	2699	2697	2694	2691	2688	2686	2684	2682
	10	2698	2695	2693	2690	2687	2685	2662	2679	2676	2673	2671	2669	2667
	20	2683	2680	2678	2675	2672	2670	2667	2664	2661	2658	2656	2654	2652
	30	2668	2665	2663	2660	2657	2655	2652	2649	2646	2643	2641	2639	2637
	40	2653	2650	2648	2645	2642	2640	2637	2634	2632	2629	2627	2625	2622
	50	2638	2635	2633	2630	2627	2625	2622	2619	2617	2614	2612	2610	2608
55	0	2624	2621	2619	2616	2613	2611	2608	2605	2602	2599	2597	2595	2593
	10	2609	2606	2604	2601	2598	2596	2593	2590	2588	2585	2583	2581	2578
	20	2594	2591	2589	2586	2583	2581	2578	2575	2573	2570	2568	2566	2564
	30	2580	2577	2575	2572	2569	2566	2564	2561	2558	2555	2553	2551	2549
	40	2565	2562	2560	2557	2554	2551	2549	2546	2544	2541	2539	2537	2535
	50	2550	2547	2545	2542	2539	2537	2535	2532	2529	2526	2524	2522	2520
56	0	2536	2533	2531	2528	2525	2523	2520	2517	2515	2512	2510	2508	2506
	10	2521	2519	2517	2514	2511	2509	2506	2503	2501	2498	2496	2494	2492
	20	2507	2504	2502	2499	2496	2494	2492	2489	2486	2483	2481	2479	2477
	30	2493	2490	2488	2485	2482	2480	2477	2474	2472	2469	2467	2465	2463
	40	2478	2476	2474	2471	2468	2466	2463	2460	2458	2455	2453	2451	2449
	50	2464	2461	2459	2456	2453	2451	2449	2446	2444	2441	2439	2437	2434
57	0	2450	2447	2445	2442	2439	2437	2435	2432	2430	2427	2425	2423	2420
	10	2436	2433	2431	2428	2425	2423	2421	2418	2415	2413	2410	2408	2406
	20	2422	2419	2417	2414	2412	2409	2407	2404	2401	2399	2396	2394	2392
	30	2408	2405	2403	2400	2398	2395	2393	2390	2387	2385	2382	2380	2378
	40	2394	2391	2389	2386	2384	2381	2379	2376	2373	2371	2368	2366	2364
	50	2380	2377	2375	2372	2370	2367	2365	2362	2360	2357	2355	2353	2351
58	0	2366	2363	2361	2358	2356	2353	2351	2348	2346	2343	2341	2339	2337
	10	2352	2349	2347	2344	2342	2339	2337	2334	2332	2329	2327	2325	2323
	20	2338	2335	2333	2330	2328	2325	2323	2320	2318	2315	2313	2311	2309
	30	2324	2322	2320	2317	2314	2312	2309	2306	2304	2301	2299	2297	2295
	40	2310	2308	2306	2303	2300	2298	2296	2293	2291	2288	2286	2284	2282
	50	2297	2294	2292	2289	2287	2284	2282	2279	2277	2274	2272	2270	2268
59	0	2283	2281	2279	2276	2273	2270	2268	2265	2263	2260	2258	2256	2254
	10	2269	2267	2265	2262	2260	2257	2255	2252	2250	2247	2245	2243	2241
	20	2256	2253	2251	2248	2246	2243	2241	2238	2236	2233	2231	2229	2227
	30	2242	2240	2238	2235	2232	2230	2228	2225	2223	2220	2218	2216	2214
	40	2229	2226	2224	2221	2218	2216	2214	2211	2209	2207	2205	2203	2201
	50	2215	2213	2211	2208	2205	2203	2201	2198	2196	2193	2191	2189	2187
60	0	2202	2200	2198	2195	2192	2190	2188	2185	2183	2180	2178	2176	2174
	10	2188	2186	2184	2181	2178	2176	2174	2171	2169	2166	2164	2162	2160
	20	2175	2173	2171	2168	2165	2163	2161	2158	2156	2153	2151	2149	2147
	30	2162	2160	2158	2155	2152	2150	2148	2145	2143	2140	2138	2136	2134
	40	2149	2146	2144	2141	2138	2136	2134	2131	2129	2127	2125	2123	2121
	50	2135	2133	2131	2128	2125	2123	2121	2118	2116	2114	2112	2110	2108
61	0	2122	2120	2118	2115	2112	2110	2108	2105	2103	2101	2099	2097	2095
	10	2109	2107	2105	2102	2099	2097	2095	2092	2090	2088	2086	2084	2082
	20	2096	2094	2092	2089	2086	2084	2082	2079	2077	2074	2072	2070	2068
	30	2083	2081	2079	2076	2073	2071	2069	2066	2064	2061	2059	2057	2055

Table C. Cor. Sec. of Par. Add.

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	4
7	3
8	1
9	0

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	4
7	3
8	1
9	0

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	5
7	3
8	2
9	1

Sec.	Cor.
0	13
1	12
2	10
3	9
4	8
5	6
6	5
7	4
8	2
9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt. ☽'s cent.		☽'s Horizontal Parallax.								Table A. Proportional part for Seconds of Parallax. Add.										
D.	M.	54′	55′	56′	57′	58′	59′	60′	61′	S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
9	30	10.55	9.56	8.57	7.58	6.59	5.59	5. 0	4. 1	0	58	57	56	55	54	53	52	51	50	49
	40	10.51	9.52	8.53	7.54	6.55	5.56	4.56	3.57	10	48	47	46	45	44	43	42	41	40	39
	50	10.48	9.49	8.49	7.50	6.51	5.52	4.53	3.54	20	38	37	36	35	34	33	32	31	30	29
10	0	10.44	9.45	8.46	7.47	6.48	5.49	4.50	3.50	30	28	27	26	25	24	24	23	22	21	20
	10	10.41	9.42	8.43	7.44	6.45	5.45	4.46	3.47	40	19	18	17	16	15	14	13	12	11	10
	20	10.38	9.39	8.40	7.41	6.41	5.42	4.43	3.44	50	9	8	7	6	5	4	3	2	1	0

Table B. For Min. of Alt. Add.

M.	S.
0	3
1	3
2	2
3	2
4	2
5	2
6	2
7	1
8	1
9	1

TABLE XIX. Logarithms.

☽'s Hor. Parallax.		Apparent Altitude of ☽'s centre.													Table C. Cor. Sec. of Par. Add.	
M.	S.	9° 30′	9° 34′	9° 38′	9° 42′	9° 46′	9° 50′	9° 54′	9° 58′	10° 2′	10° 6′	10° 10′	10° 14′	10° 18′	Sec.	Cor.
54	0	2679	2676	2673	2669	2666	2663	2660	2657	2654	2651	2648	2645	2642	0	13
	10	2664	2661	2658	2654	2651	2648	2645	2642	2640	2637	2634	2631	2628	1	12
	20	2649	2646	2643	2639	2636	2633	2630	2627	2625	2622	2619	2616	2613	2	10
	30	2634	2631	2628	2624	2621	2618	2615	2612	2610	2607	2604	2601	2598	3	9
	40	2619	2616	2613	2610	2607	2604	2601	2598	2595	2592	2589	2587	2584	4	7
	50	2605	2602	2599	2595	2592	2589	2586	2583	2581	2578	2575	2572	2569	5	6
55	0	2590	2587	2584	2580	2577	2574	2571	2568	2566	2563	2560	2557	2554	6	4
	10	2575	2572	2569	2566	2563	2560	2557	2554	2552	2549	2546	2543	2540	7	3
	20	2561	2558	2555	2551	2548	2545	2542	2539	2537	2534	2531	2528	2525	8	2
	30	2546	2543	2540	2537	2534	2531	2528	2525	2523	2520	2517	2514	2511	9	0
	40	2532	2529	2526	2523	2520	2517	2514	2511	2508	2505	2502	2500	2497		
	50	2517	2514	2511	2508	2505	2502	2499	2496	2494	2491	2488	2485	2482	Sec.	Cor.
56	0	2503	2500	2497	2494	2491	2488	2485	2482	2480	2477	2474	2471	2468	0	13
	10	2489	2486	2483	2480	2477	2474	2471	2468	2465	2462	2459	2457	2454	1	12
	20	2474	2471	2468	2465	2462	2459	2456	2453	2451	2448	2445	2443	2440	2	10
	30	2460	2457	2454	2451	2448	2445	2442	2439	2437	2434	2431	2428	2425	3	9
	40	2446	2443	2440	2437	2434	2431	2428	2425	2423	2420	2417	2414	2411	4	7
	50	2432	2429	2426	2423	2420	2417	2414	2411	2409	2406	2403	2400	2397	5	6
57	0	2418	2415	2412	2409	2406	2403	2400	2397	2395	2392	2389	2386	2383	6	5
	10	2404	2401	2398	2395	2392	2389	2386	2383	2381	2378	2375	2372	2369	7	3
	20	2390	2387	2384	2381	2378	2375	2372	2369	2367	2364	2361	2358	2355	8	2
	30	2376	2373	2370	2367	2364	2361	2358	2355	2353	2350	2347	2345	2342	9	0
	40	2362	2359	2356	2353	2350	2347	2344	2341	2339	2336	2333	2331	2328		
	50	2348	2345	2342	2339	2336	2333	2330	2327	2325	2322	2319	2317	2314	Sec.	Cor.
58	0	2334	2331	2328	2325	2322	2319	2316	2313	2311	2308	2306	2303	2300	0	13
	10	2320	2317	2314	2311	2308	2306	2303	2300	2298	2295	2292	2290	2287	1	12
	20	2306	2303	2300	2297	2294	2292	2289	2286	2284	2281	2278	2276	2273	2	10
	30	2293	2290	2287	2284	2281	2278	2275	2272	2270	2267	2264	2262	2259	3	9
	40	2279	2276	2273	2270	2267	2265	2262	2259	2257	2254	2251	2249	2246	4	8
	50	2265	2262	2259	2257	2254	2251	2248	2245	2243	2240	2237	2235	2232	5	6
59	0	2252	2249	2246	2243	2240	2238	2235	2232	2230	2227	2224	2222	2219	6	5
	10	2238	2235	2233	2230	2227	2224	2221	2218	2216	2213	2210	2208	2205	7	4
	20	2225	2222	2219	2216	2213	2211	2208	2205	2203	2200	2197	2195	2192	8	2
	30	2211	2208	2206	2203	2200	2197	2194	2191	2189	2186	2184	2182	2179	9	1
	40	2198	2195	2192	2189	2186	2184	2181	2178	2176	2173	2170	2168	2165		
	50	2185	2182	2179	2176	2173	2171	2168	2165	2163	2160	2157	2155	2152	Sec.	Cor.
60	0	2171	2168	2166	2163	2160	2158	2155	2152	2150	2147	2144	2142	2139	0	13
	10	2158	2155	2152	2149	2146	2144	2141	2138	2136	2133	2131	2129	2126	1	12
	20	2145	2142	2139	2136	2133	2131	2128	2125	2123	2120	2117	2115	2112	2	10
	30	2132	2129	2126	2123	2120	2118	2115	2112	2110	2107	2104	2102	2099	3	9
	40	2118	2115	2113	2110	2107	2105	2102	2099	2097	2094	2091	2089	2086	4	8
	50	2105	2102	2100	2097	2094	2092	2089	2086	2084	2081	2078	2076	2073	5	6
61	0	2092	2089	2087	2084	2081	2079	2076	2073	2071	2068	2065	2063	2060	6	5
	10	2079	2076	2074	2071	2068	2066	2063	2060	2058	2055	2052	2050	2047	7	4
	20	2066	2063	2061	2058	2055	2053	2050	2047	2045	2042	2039	2037	2034	8	2
	30	2053	2050	2048	2045	2042	2040	2037	2034	2032	2029	2027	2025	2022	9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt. ☽'s cen. D.	M.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Table A. Proportional part for Seconds of Parallax. Add. S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
10	20	10.38	9.39	8.40	7.41	6.41	5.42	4.43	3.44	0	58	57	56	55	54	53	52	51	50	49
	30	10.35	9.36	8.37	7.38	6.39	5.40	4.41	3.42	10	48	47	46	45	44	43	42	41	40	39
	40	10.32	9.33	8.34	7.35	6.36	5.37	4.38	3.39	20	38	37	36	35	34	33	32	31	30	29
	50	10.29	9.30	8.31	7.32	6.33	5.34	4.35	3.36	30	29	28	27	26	25	24	23	22	21	20
11	0	10.27	9.28	8.29	7.30	6.31	5.32	4.33	3.34	40	19	18	17	16	15	14	13	12	11	10
	10	10.24	9.25	8.26	7.27	6.29	5.30	4.31	3.32	50	9	8	7	6	5	4	3	2	1	0

Table B. For Min. of Alt. Add.

M.	S.
0	3
1	3
2	2
3	2
4	2
5	2
6	1
7	1
8	1
9	1

TABLE XIX. Logarithms.

☽'s Hor. Parallax. M.	S.	Apparent Altitude of ☽'s centre. 10° 22′	10° 26′	10° 30′	10° 34′	10° 38′	10° 42′	10° 46′	10° 50′	10° 54′	10° 58′	11° 2′	11° 6′	Table C. Corr. for Sec of Parallax. Add. Sec.	Cor.
54	0	2639	2637	2634	2631	2628	2626	2623	2621	2618	2616	2614	2611	0	13
	10	2625	2622	2619	2616	2613	2611	2608	2606	2603	2601	2599	2597	1	12
	20	2610	2608	2605	2602	2599	2597	2594	2591	2588	2586	2584	2582	2	10
	30	2595	2593	2590	2587	2584	2582	2579	2577	2574	2572	2570	2567	3	9
	40	2581	2578	2575	2572	2570	2568	2565	2562	2560	2557	2555	2552	4	7
	50	2566	2564	2561	2558	2555	2553	2550	2548	2545	2543	2541	2538	5	6
55	0	2551	2549	2546	2543	2540	2538	2535	2533	2530	2528	2526	2523	6	4
	10	2537	2535	2532	2529	2526	2524	2521	2519	2516	2514	2512	2509	7	3
	20	2522	2520	2517	2514	2512	2510	2507	2504	2502	2499	2497	2495	8	2
	30	2508	2506	2503	2500	2497	2495	2492	2490	2487	2485	2483	2480	9	0
	40	2494	2492	2489	2486	2483	2481	2478	2476	2473	2471	2469	2466		
	50	2479	2477	2474	2471	2469	2467	2464	2462	2459	2457	2455	2452	Sec.	Cor
56	0	2465	2463	2460	2457	2455	2453	2450	2447	2445	2442	2440	2438	0	13
	10	2451	2449	2446	2443	2440	2438	2435	2433	2430	2428	2426	2424	1	12
	20	2437	2435	2432	2429	2426	2424	2421	2419	2416	2414	2412	2410	2	10
	30	2423	2420	2418	2415	2412	2410	2407	2405	2402	2400	2398	2396	3	9
	40	2409	2406	2404	2401	2398	2396	2393	2391	2388	2386	2384	2382	4	7
	50	2395	2392	2390	2387	2384	2382	2379	2377	2374	2372	2370	2368	5	6
57	0	2381	2378	2376	2373	2370	2368	2365	2363	2360	2358	2356	2354	6	5
	10	2367	2364	2362	2359	2356	2354	2351	2349	2346	2344	2342	2340	7	3
	20	2353	2350	2348	2345	2342	2340	2337	2335	2333	2331	2329	2326	8	2
	30	2339	2337	2334	2331	2329	2327	2324	2322	2319	2317	2315	2312	9	0
	40	2325	2323	2320	2317	2315	2313	2310	2308	2305	2303	2301	2299		
	50	2311	2309	2306	2303	2301	2299	2296	2294	2291	2289	2287	2285	Sec.	Cor.
58	0	2298	2295	2293	2290	2288	2286	2283	2281	2278	2276	2274	2271	0	13
	10	2284	2282	2279	2276	2274	2272	2269	2267	2264	2262	2260	2258	1	12
	20	2270	2268	2265	2262	2260	2258	2255	2253	2251	2249	2247	2244	2	10
	30	2257	2254	2252	2249	2247	2245	2242	2240	2237	2235	2233	2231	3	9
	40	2243	2241	2238	2235	2233	2231	2228	2226	2224	2222	2220	2217	4	8
	50	2230	2227	2225	2222	2220	2218	2215	2213	2210	2208	2206	2204	5	6
59	0	2216	2214	2211	2208	2206	2204	2201	2199	2197	2195	2193	2191	6	5
	10	2203	2200	2198	2195	2193	2191	2188	2186	2183	2181	2179	2177	7	4
	20	2190	2187	2185	2182	2180	2178	2175	2173	2170	2168	2166	2164	8	2
	30	2176	2174	2171	2168	2166	2164	2161	2159	2157	2155	2153	2151	9	1
	40	2163	2160	2158	2155	2153	2151	2148	2146	2144	2142	2140	2138		
	50	2150	2147	2145	2142	2140	2138	2135	2133	2130	2128	2126	2124	Sec.	Cor.
60	0	2137	2134	2132	2129	2127	2125	2122	2120	2117	2115	2113	2111	0	13
	10	2123	2121	2118	2115	2113	2111	2109	2107	2104	2102	2100	2098	1	12
	20	2110	2107	2105	2102	2100	2098	2096	2094	2091	2089	2087	2085	2	10
	30	2097	2094	2092	2089	2087	2085	2083	2081	2078	2076	2074	2072	3	9
	40	2084	2081	2079	2076	2074	2072	2070	2068	2065	2063	2061	2059	4	8
	50	2071	2068	2066	2063	2061	2059	2057	2055	2052	2050	2048	2046	5	6
61	0	2058	2055	2053	2050	2048	2046	2044	2042	2039	2037	2035	2033	6	5
	10	2045	2042	2040	2037	2035	2033	2031	2029	2026	2024	2022	2020	7	4
	20	2032	2029	2027	2024	2022	2020	2018	2016	2014	2012	2010	2008	8	2
	30	2020	2017	2015	2012	2009	2007	2005	2003	2001	1999	1997	1995	9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt. D's cen. D.	M.	D's Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	TABLE A. Proportional part for Seconds of Parallax. Add. S.	0″	1″	2″	3″	4″	5″	6″	7′	8	9′
11	10	10.25	9.26	8.27	7.28	6.30	5.31	4.32	3.33	0	58	57	56	55	54	53	52	51	50	49
	20	10.23	9.24	8.25	7.26	6.28	5.29	4.30	3.31	10	48	47	46	45	44	43	42	41	40	39
	30	10.21	9.22	8.23	7.24	6.26	5.27	4.28	3.29	20	38	37	36	35	34	33	33	32	31	30
	40	10.19	9.20	8.21	7.22	6.24	5.25	4.26	3.27	30	29	28	27	26	25	24	23	22	21	20
	50	10.17	9.18	8.19	7.21	6.22	5.23	4.24	3.26	40	19	18	17	16	15	14	13	12	11	10
12	0	10.15	9.16	8.18	7.19	6.20	5.22	4.23	3.24	50	9	8	7	6	5	4	3	2	1	0

TABLE B. For Min of Alt. Add. M.	S.
0	2
1	2
2	2
3	1
4	1
5	1
6	1
7	1
8	0
9	0

TABLE XIX. Logarithms.

D's Hor. Parallax. M.	S.	Apparent Altitude of D's centre. 11° 10′	11° 15′	11° 20′	11° 25′	11° 30′	11° 35′	11° 40′	11° 45′	11° 50′	11° 55′	12° 0′	TABLE C. Cor. for Sec. of Parallax. Add. Sec.	Cor.
54	0	2609	2606	2603	2600	2597	2594	2592	2589	2586	2584	2581	0	13
	10	2594	2591	2588	2585	2582	2579	2577	2574	2571	2569	2566	1	12
	20	2579	2576	2573	2571	2568	2565	2563	2560	2557	2555	2552	2	10
	30	2565	2562	2559	2556	2553	2550	2548	2545	2542	2540	2537	3	9
	40	2550	2547	2544	2542	2539	2536	2534	2531	2528	2526	2523	4	7
	50	2536	2533	2530	2527	2524	2521	2519	2516	2513	2511	2508	5	6
55	0	2521	2518	2515	2513	2510	2507	2505	2502	2499	2497	2494	6	4
	10	2507	2504	2501	2498	2495	2492	2490	2487	2485	2482	2480	7	3
	20	2493	2490	2487	2484	2481	2478	2476	2473	2470	2468	2465	8	2
	30	2478	2475	2472	2470	2467	2464	2462	2459	2456	2454	2451	9	0
	40	2464	2461	2458	2456	2453	2450	2448	2445	2442	2440	2437		
	50	2450	2447	2444	2442	2439	2436	2434	2431	2428	2426	2423	Sec.	Cor.
56	0	2436	2433	2430	2427	2424	2421	2419	2416	2414	2411	2409	0	13
	10	2422	2419	2416	2413	2410	2407	2405	2402	2400	2397	2395	1	12
	20	2408	2405	2402	2399	2396	2393	2391	2388	2386	2383	2381	2	10
	30	2394	2391	2388	2385	2382	2379	2377	2374	2372	2369	2367	3	9
	40	2380	2377	2374	2371	2368	2365	2363	2360	2358	2355	2353	4	7
	50	2366	2363	2360	2357	2354	2352	2349	2347	2344	2342	2339	5	6
57	0	2352	2349	2346	2344	2341	2338	2336	2333	2330	2328	2325	6	5
	10	2338	2335	2332	2330	2327	2324	2322	2319	2317	2314	2312	7	3
	20	2324	2321	2318	2316	2313	2310	2308	2305	2303	2300	2298	8	2
	30	2310	2307	2304	2302	2299	2297	2294	2292	2289	2287	2284	9	0
	40	2297	2294	2291	2289	2286	2283	2281	2278	2276	2273	2271		
	50	2283	2280	2277	2275	2272	2269	2267	2264	2262	2259	2257	Sec.	Cor.
58	0	2269	2266	2263	2261	2258	2256	2253	2251	2248	2246	2243	0	13
	10	2256	2253	2250	2248	2245	2242	2240	2237	2235	2232	2230	1	12
	20	2242	2239	2236	2234	2231	2229	2226	2224	2221	2219	2216	2	10
	30	2229	2226	2223	2221	2218	2215	2213	2210	2208	2205	2203	3	9
	40	2215	2212	2209	2207	2204	2202	2199	2197	2195	2192	2190	4	8
	50	2202	2199	2196	2194	2191	2189	2186	2184	2181	2179	2176	5	6
59	0	2189	2186	2183	2181	2178	2175	2173	2170	2168	2165	2163	6	5
	10	2175	2172	2169	2167	2164	2162	2159	2157	2155	2152	2150	7	4
	20	2162	2159	2156	2154	2151	2149	2146	2144	2141	2139	2136	8	2
	30	2149	2146	2143	2141	2138	2135	2133	2130	2128	2125	2123	9	1
	40	2136	2133	2130	2128	2125	2122	2120	2117	2115	2112	2110		
	50	2122	2119	2117	2114	2112	2109	2107	2104	2102	2099	2097	Sec.	Cor.
60	0	2109	2106	2104	2101	2099	2096	2094	2091	2089	2086	2084	0	13
	10	2096	2093	2091	2088	2086	2083	2081	2078	2076	2073	2071	1	12
	20	2083	2080	2078	2075	2073	2070	2068	2065	2063	2060	2058	2	10
	30	2070	2067	2065	2062	2060	2057	2055	2052	2050	2047	2045	3	9
	40	2057	2054	2052	2049	2047	2044	2042	2039	2037	2034	2032	4	8
	50	2044	2041	2039	2036	2034	2031	2029	2026	2024	2021	2019	5	6
61	0	2031	2028	2026	2023	2021	2018	2016	2013	2011	2008	2006	6	5
	10	2018	2015	2013	2010	2008	2006	2003	2001	1999	1996	1994	7	4
	20	2006	2003	2000	1998	1995	1993	1990	1988	1986	1983	1981	8	2
	30	1993	1990	1987	1985	1982	1980	1977	1975	1973	1970	1968	9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt. D's cen. D.	M.	D's Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Table A. Proportional part for Seconds of Parallax. Add. S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9
12	0	10.16	9.17	8.19	7.20	6.21	5.23	4.24	3.25	0	58	57	56	55	54	53	52	51	50	49
	10	10.15	9.16	8.17	7.19	6.20	5.21	4.23	3.24	10	48	47	46	45	44	43	42	41	40	39
	20	10.13	9.14	8.16	7.17	6.19	5.20	4.21	3.23	20	38	37	37	36	35	34	33	32	31	30
	30	10.12	9.13	8.14	7.16	6.17	5.19	4.20	3.22	30	29	28	27	26	25	24	23	22	21	20
	40	10.10	9.12	8.13	7.15	6.16	5.18	4.19	3.21	40	19	18	17	16	15	14	13	12	11	10
	50	10. 9	9.11	8.12	7.14	6.15	5.17	4.18	3.20	50	9	8	7	6	5	4	3	2	1	0

Table B. For Min of Alt. Add.

M.	S.
0	1
1	1
2	1
3	1
4	1
5	1
6	0
7	0
8	0
9	0

TABLE XIX. Logarithms.

D's Hor. Parallax. M.	S.	Apparent Altitude of D's centre. 12° 5′	12° 10′	12° 15′	12° 20′	12° 25′	12° 30′	12° 35′	12° 40′	12° 45′	12° 50′	12° 55′
54	0	2578	2576	2573	2571	2568	2566	2564	2561	2559	2557	2554
	10	2564	2561	2559	2556	2554	2551	2549	2546	2544	2542	2540
	20	2549	2547	2544	2542	2539	2537	2535	2532	2530	2528	2525
	30	2534	2532	2529	2527	2524	2522	2520	2517	2515	2513	2511
	40	2520	2518	2515	2513	2510	2508	2506	2503	2501	2499	2496
	50	2506	2503	2501	2499	2496	2494	2492	2489	2487	2485	2482
55	0	2491	2489	2486	2484	2481	2479	2477	2474	2472	2470	2468
	10	2477	2475	2472	2470	2467	2465	2463	2460	2458	2456	2454
	20	2463	2461	2458	2456	2453	2451	2449	2446	2444	2442	2439
	30	2449	2447	2444	2442	2439	2437	2435	2432	2430	2428	2425
	40	2435	2433	2430	2428	2425	2423	2421	2418	2416	2414	2411
	50	2421	2419	2416	2414	2411	2409	2407	2404	2402	2400	2397
56	0	2407	2405	2402	2400	2397	2395	2393	2390	2388	2386	2383
	10	2393	2391	2388	2386	2383	2381	2379	2376	2374	2372	2369
	20	2379	2377	2374	2372	2369	2367	2365	2362	2360	2358	2355
	30	2365	2363	2360	2358	2355	2353	2351	2348	2346	2344	2341
	40	2351	2349	2346	2344	2341	2339	2337	2334	2332	2330	2328
	50	2337	2335	2332	2330	2327	2325	2323	2320	2318	2316	2314
57	0	2323	2321	2318	2316	2313	2311	2309	2307	2305	2303	2300
	10	2310	2307	2304	2302	2300	2298	2296	2293	2291	2289	2287
	20	2296	2294	2291	2289	2286	2284	2282	2279	2277	2275	2273
	30	2282	2280	2277	2275	2272	2270	2268	2266	2264	2262	2259
	40	2269	2266	2263	2261	2259	2257	2255	2252	2250	2248	2246
	50	2255	2252	2250	2248	2245	2243	2241	2239	2237	2235	2232
58	0	2241	2238	2236	2234	2232	2230	2228	2225	2223	2221	2219
	10	2228	2225	2223	2221	2218	2216	2214	2212	2210	2208	2205
	20	2214	2211	2209	2207	2205	2203	2201	2198	2196	2194	2192
	30	2201	2198	2196	2194	2191	2189	2187	2185	2183	2181	2179
	40	2188	2185	2183	2181	2178	2176	2174	2172	2170	2168	2165
	50	2174	2171	2169	2167	2165	2163	2161	2158	2156	2154	2152
59	0	2161	2158	2156	2154	2151	2149	2147	2145	2143	2141	2139
	10	2148	2145	2143	2141	2138	2136	2134	2132	2130	2128	2126
	20	2134	2132	2130	2128	2125	2123	2121	2119	2117	2115	2113
	30	2121	2118	2116	2114	2112	2110	2108	2106	2104	2102	2100
	40	2108	2105	2103	2101	2099	2097	2095	2092	2090	2088	2086
	50	2095	2092	2090	2088	2086	2084	2082	2079	2077	2075	2073
60	0	2082	2079	2077	2075	2073	2071	2069	2066	2064	2062	2060
	10	2069	2066	2064	2062	2060	2058	2056	2054	2052	2050	2048
	20	2056	2053	2051	2049	2047	2045	2043	2041	2039	2037	2035
	30	2043	2040	2038	2036	2034	2032	2030	2028	2026	2024	2022
	40	2030	2027	2025	2023	2021	2019	2017	2015	2013	2011	2009
	50	2017	2015	2013	2011	2008	2006	2004	2002	2000	1998	1996
61	0	2004	2002	2000	1998	1995	1993	1991	1989	1987	1985	1983
	10	1992	1989	1987	1985	1983	1981	1979	1977	1975	1973	1970
	20	1979	1976	1974	1972	1970	1968	1966	1964	1962	1960	1958
	30	1966	1964	1962	1960	1957	1955	1953	1951	1949	1947	1945

Table C. Cor. for Sec. of Parallax. Add.

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	4
7	3
8	2
9	0

Sec.	Cor.
0	13
1	12
2	10
3	9
4	7
5	6
6	5
7	3
8	2
9	0

Sec.	Cor.
0	13
1	12
2	10
3	9
4	8
5	6
6	5
7	4
8	2
9	1

Sec.	Cor.
0	13
1	12
2	10
3	9
4	8
5	6
6	5
7	4
8	2
9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt. ☽'s cen. D.	M.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Table A. Proportional part for Seconds of Parallax. Add. S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	Table B For Min. of Alt. Add. M.	S.
13	0	10.10	9.12	8.13	7.15	6.16	5.18	4.19	3.21	0	57	56	55	54	53	52	51	50	49	48	0	0
	10	10. 9	9.11	8.12	7.14	6.15	5 17	4.19	3.20	10	47	46	45	44	43	42	41	40	39	39	1 2	0 0
	20	10. 8	9.10	8.12	7.13	6.15	5.16	4.18	3.20	20	38	37	36	35	34	33	32	31	30	29	3 4	0 0
	30	10. 8	9. 9	8.11	7.13	6.14	5.16	4.17	3.19	30	28	27	26	25	24	23	22	21	20	19	5 6	0 0
	40	10. 7	9. 9	8.10	7.12	6.14	5.15	4.17	3.19	40	18	17	16	15	14	13	12	11	10	9	7	0
	50	10. 6	9. 8	8.10	7.12	6.13	5.15	4.17	3.18	50	8	7	6	5	4	4	3	2	1	0	8 9	0 0

TABLE XIX. Logarithms.

☽'s Hor. Parallax. M.	S.	Apparent Altitude of ☽'s centre. 13° 0′	13° 5′	13° 10′	13° 15′	13° 20′	13° 25′	13° 30′	13° 35′	13° 40′	13° 45′	13° 50′	13° 55′	Table C. Cor. Sec. of Par. Add. Sec.	Cor.
54	0	2552	2550	2548	2545	2543	2541	2539	2537	2535	2533	2531	2529	0	13
	10	2538	2536	2534	2531	2529	2527	2525	2523	2521	2519	2517	2515	1	12
	20	2523	2521	2519	2517	2515	2513	2511	2509	2507	2505	2503	2501	2	10
	30	2509	2507	2505	2502	2500	2498	2496	2494	2492	2490	2488	2486	3	9
	40	2494	2492	2490	2488	2486	2484	2482	2480	2478	2476	2474	2472	4	7
	50	2480	2478	2476	2474	2472	2470	2468	2466	2464	2462	2460	2458	5	6
55	0	2466	2464	2462	2460	2458	2456	2454	2452	2450	2448	2446	2444	6	5
	10	2452	2450	2448	2446	2444	2442	2440	2438	2436	2434	2432	2430	7	3
	20	2437	2435	2433	2431	2429	2427	2425	2423	2421	2419	2417	2415	8	2
	30	2423	2421	2419	2417	2415	2413	2411	2409	2407	2405	2403	2401	9	0
	40	2409	2407	2405	2403	2401	2399	2397	2395	2393	2391	2389	2387		
	50	2395	2393	2391	2389	2387	2385	2383	2381	2379	2377	2375	2373	Sec.	Cor.
56	0	2381	2379	2377	2375	2373	2371	2369	2367	2365	2364	2362	2360	0	13
	10	2367	2365	2363	2361	2359	2357	2355	2353	2351	2350	2348	2346	1	12
	20	2353	2351	2349	2347	2345	2343	2341	2339	2337	2336	2334	2332	2	10
	30	2339	2337	2335	2333	2331	2329	2327	2325	2323	2322	2320	2318	3	9
	40	2326	2324	2322	2320	2318	2316	2314	2312	2310	2308	2306	2304	4	8
	50	2312	2310	2308	2306	2304	2302	2300	2298	2296	2295	2293	2291	5	6
57	0	2298	2296	2294	2292	2290	2288	2286	2284	2282	2281	2279	2277	6	5
	10	2285	2283	2281	2279	2277	2275	2273	2271	2269	2267	2265	2263	7	3
	20	2271	2269	2267	2265	2263	2261	2259	2257	2255	2254	2252	2250	8	2
	30	2257	2255	2253	2251	2249	2247	2245	2243	2241	2240	2238	2236	9	1
	40	2244	2242	2240	2238	2236	2234	2232	2230	2228	2227	2225	2223		
	50	2230	2228	2226	2224	2222	2220	2218	2216	2214	2213	2211	2209	Sec.	Cor.
58	0	2217	2215	2213	2211	2209	2207	2205	2203	2201	2200	2198	2196	0	13
	10	2203	2201	2199	2198	2196	2194	2192	2190	2188	2187	2185	2183	1	12
	20	2190	2188	2186	2184	2182	2180	2178	2176	2174	2173	2171	2169	2	10
	30	2177	2175	2173	2171	2169	2167	2165	2163	2161	2160	2158	2156	3	9
	40	2163	2161	2159	2158	2156	2154	2152	2150	2148	2147	2145	2143	4	8
	50	2150	2148	2146	2145	2143	2141	2139	2137	2135	2134	2132	2130	5	6
59	0	2137	2135	2133	2131	2129	2127	2125	2123	2122	2120	2118	2117	6	5
	10	2124	2122	2120	2118	2110	2114	2112	2110	2108	2107	2105	2103	7	4
	20	2111	2109	2107	2105	2103	2101	2099	2097	2095	2094	2092	2090	8	3
	30	2098	2096	2094	2092	2090	2088	2086	2084	2082	2081	2079	2077	9	1
	40	2085	2083	2081	2079	2077	2075	2073	2071	2069	2068	2066	2064		
	50	2072	2070	2068	2066	2064	2062	2060	2058	2056	2055	2053	2051	Sec.	Cor.
60	0	2059	2057	2055	2053	2051	2049	2047	2045	2043	2042	2040	2038	0	13
	10	2046	2044	2042	2040	2038	2036	2034	2032	2031	2029	2027	2026	1	12
	20	2033	2031	2029	2027	2025	2023	2021	2019	2018	2016	2014	2013	2	10
	30	2020	2018	2016	2014	2012	2010	2008	2006	2005	2003	2001	2000	3	9
	40	2007	2005	2003	2002	2000	1998	1996	1994	1992	1990	1989	1987	4	8
	50	1994	1992	1990	1989	1987	1985	1983	1981	1979	1977	1976	1974	5	7
61	0	1981	1979	1977	1976	1974	1972	1970	1968	1967	1965	1963	1962	6	5
	10	1969	1967	1965	1963	1961	1959	1957	1955	1954	1952	1950	1949	7	4
	20	1956	1954	1952	1951	1949	1947	1945	1943	1942	1940	1938	1937	8	3
	30	1943	1941	1939	1938	1936	1934	1932	1930	1929	1927	1925	1924	9	2

Digitized by Google

TABLE XIX.

Correction.

App. Alt. ☽'s cen.		☽'s Horizontal Parallax.							
D.	M.	54′	55′	56′	57′	58′	59′	60′	61′
14	0	10. 6	9. 8	8. 9	7.11	6.13	5.15	4.17	3.18
	10	10. 5	9. 7	8. 9	7.11	6.13	5.15	4.16	3.18
	20	10. 5	9. 7	8. 9	7.11	6.13	5.14	4.16	3.18
	30	10. 5	9. 7	8. 9	7.11	6.13	5.14	4.16	3.18
	40	10. 5	9. 7	8. 9	7.11	6.13	5.15	4.16	3.18
	50	10. 5	9. 7	8. 9	7.11	6.13	5.15	4.17	3.19

TABLE A. Proportional part for Seconds of Parallax. Add.

S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
0	57	56	55	54	53	52	51	50	49	48
10	47	46	45	44	43	42	42	41	40	39
20	38	37	36	35	34	33	32	31	30	29
30	28	27	26	25	24	23	22	21	20	19
40	18	17	16	15	14	13	12	11	11	10
50	9	8	7	6	5	4	3	2	1	0

TABLE B. For Min. of Alt. Add.

M.	S.
0	0
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

TABLE XIX. Logarithms.

☽'s Hor. Parallax.		Apparent Altitude of ☽'s centre.												TABLE C. Cor. Sec. of Par. Add.	
M.	S.	14° 0′	14° 5′	14° 10′	14° 15′	14° 20′	14° 25′	14° 30′	14° 35′	14° 40′	14° 45′	14° 50′	14° 55′	Sec.	Cor.
54	0	2527	2525	2523	2521	2520	2518	2516	2514	2513	2511	2509	2508	0	13
	10	2513	2511	2509	2507	2506	2504	2502	2500	2499	2497	2495	2494	1	12
	20	2499	2497	2495	2493	2492	2490	2488	2486	2485	2483	2481	2480	2	10
	30	2484	2482	2480	2478	2477	2475	2473	2471	2470	2468	2466	2465	3	9
	40	2470	2468	2466	2464	2463	2461	2459	2457	2456	2454	2452	2451	4	7
	50	2456	2454	2452	2450	2449	2447	2445	2443	2442	2440	2438	2437	5	6
55	0	2442	2440	2438	2436	2435	2433	2431	2429	2428	2426	2424	2423	6	5
	10	2428	2426	2424	2422	2421	2419	2417	2415	2414	2412	2410	2409	7	3
	20	2413	2412	2410	2408	2406	2405	2403	2401	2400	2398	2396	2395	8	2
	30	2399	2398	2396	2394	2392	2391	2389	2387	2386	2384	2382	2381	9	0
	40	2385	2384	2382	2380	2378	2377	2375	2373	2372	2370	2368	2367		
	50	2371	2370	2368	2366	2364	2363	2361	2359	2358	2356	2354	2353	Sec.	Cor.
56	0	2358	2356	2354	2352	2351	2349	2347	2345	2344	2342	2340	2339	0	13
	10	2344	2342	2340	2338	2337	2335	2333	2331	2330	2328	2326	2325	1	12
	20	2330	2328	2326	2324	2323	2321	2319	2317	2316	2315	2313	2312	2	10
	30	2316	2314	2313	2311	2309	2308	2306	2304	2303	2301	2299	2298	3	9
	40	2302	2300	2299	2297	2295	2294	2292	2290	2289	2287	2285	2284	4	8
	50	2289	2287	2285	2283	2282	2280	2278	2276	2275	2274	2272	2271	5	6
57	0	2275	2273	2272	2270	2268	2267	2265	2263	2262	2260	2258	2257	6	5
	10	2261	2259	2258	2256	2254	2253	2251	2249	2248	2246	2244	2243	7	3
	20	2248	2246	2245	2243	2241	2240	2238	2236	2235	2233	2231	2230	8	2
	30	2234	2232	2231	2229	2227	2226	2224	2222	2221	2219	2217	2216	9	1
	40	2221	2219	2218	2216	2214	2213	2211	2209	2208	2206	2204	2203		
	50	2207	2205	2204	2202	2200	2199	2197	2195	2194	2193	2191	2190	Sec.	Cor.
58	0	2194	2192	2191	2189	2187	2186	2184	2182	2181	2179	2177	2176	0	13
	10	2181	2179	2178	2176	2174	2173	2171	2169	2168	2166	2164	2163	1	12
	20	2167	2165	2164	2162	2160	2159	2157	2155	2154	2153	2151	2150	2	10
	30	2154	2152	2151	2149	2147	2146	2144	2142	2141	2140	2138	2137	3	9
	40	2141	2139	2138	2136	2134	2133	2131	2129	2128	2126	2124	2123	4	8
	50	2128	2126	2125	2123	2121	2120	2118	2116	2115	2113	2111	2110	5	6
59	0	2115	2113	2112	2110	2108	2107	2105	2103	2102	2100	2098	2097	6	5
	10	2101	2099	2098	2096	2094	2093	2091	2089	2088	2087	2085	2084	7	4
	20	2088	2086	2085	2083	2081	2080	2078	2076	2075	2074	2072	2071	8	3
	30	2075	2073	2072	2070	2068	2067	2065	2063	2062	2061	2059	2058	9	1
	40	2062	2060	2059	2057	2055	2054	2052	2050	2049	2048	2046	2045		
	50	2049	2047	2046	2045	2043	2042	2040	2038	2037	2035	2033	2032	Sec.	Cor.
60	0	2036	2034	2033	2032	2030	2029	2027	2025	2024	2022	2020	2019	0	13
	10	2024	2022	2021	2019	2017	2016	2014	2012	2011	2010	2008	2007	1	12
	20	2011	2009	2008	2006	2004	2003	2001	1999	1998	1997	1995	1994	2	10
	30	1998	1996	1995	1993	1991	1990	1988	1986	1985	1984	1982	1981	3	9
	40	1985	1983	1982	1980	1978	1977	1975	1973	1972	1971	1969	1968	4	8
	50	1972	1970	1969	1968	1966	1965	1963	1961	1960	1959	1957	1956	5	7
61	0	1960	1958	1957	1955	1953	1952	1950	1948	1947	1946	1944	1943	6	5
	10	1947	1945	1944	1942	1940	1939	1937	1935	1934	1933	1931	1930	7	4
	20	1935	1933	1932	1930	1928	1927	1925	1923	1922	1921	1919	1918	8	3
	30	1922	1920	1919	1917	1915	1914	1912	1910	1909	1908	1906	1905	9	2

Digitized by Google

App. Alt. ☽'s cen. D.	M.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Table A. Proportional part for Seconds of Parallax. Add. S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
15	0	10. 5	9. 7	8. 9	7.11	6.13	5.15	4.17	3.19	0	57	56	55	54	53	52	51	50	49	48
	10	10. 5	9. 7	8. 9	7.11	6.13	5.15	4.17	3.19	10	47	46	45	44	43	43	42	41	40	39
	20	10. 5	9. 7	8. 9	7.11	6.13	5.16	4.18	3.20	20	38	37	36	35	34	33	32	31	30	29
	30	10. 5	9. 7	8.10	7.12	6.14	5.16	4.18	3.20	30	28	27	26	25	24	23	22	21	20	19
	40	10. 6	9. 8	8.10	7.12	6.14	5.17	4.19	3.21	40	18	17	16	16	15	14	13	12	11	10
	50	10. 6	9. 8	8.10	7.13	6.15	5.17	4.19	3.22	50	9	8	7	6	5	4	3	2	1	0
16	0	10. 6	9. 9	8.11	7.13	6.16	5.18	4.20	3.23	0	57	56	55	54	53	52	51	50	49	48
	10	10. 7	9. 9	8.12	7.14	6.16	5.19	4.21	3.23	10	47	46	45	45	44	43	42	41	40	39
	20	10. 7	9.10	8.12	7.15	6.17	5.20	4.22	3.24	20	38	37	36	35	34	33	32	31	30	29
	30	10. 8	9.11	8.13	7.15	6.18	5.20	4.23	3.25	30	28	27	26	25	24	23	22	21	21	20
	40	10. 9	9.11	8.14	7.16	6.19	5.21	4.24	3.26	40	19	18	17	16	15	14	13	12	11	10
	50	10.10	9.12	8.15	7.17	6.20	5.22	4.25	3.27	50	9	8	7	6	5	4	3	2	1	0

Table B For Min. of Alt. Add.

M.	S.
0	0
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
0	0
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	1
9	1

TABLE XIX. Logarithms.

☽'s Hor. Parallax. M.	S.	Apparent Altitude of ☽'s centre. 15° 0′	15° 10′	15° 20′	15° 30′	15° 40′	15° 50′	16° 0′	16° 10′	16° 20′	16° 30′	16° 40′	16° 50′	Table C. Cor. Sec. of Par. Add. Sec.	Cor.
54	0	2506	2503	2500	2497	2494	2491	2488	2485	2482	2479	2476	2474	0	13
	10	2492	2488	2485	2482	2479	2476	2473	2471	2468	2465	2462	2460	1	12
	20	2478	2474	2471	2468	2465	2462	2459	2457	2454	2451	2448	2446	2	10
	30	2463	2460	2457	2454	2451	2448	2445	2442	2439	2436	2434	2431	3	9
	40	2449	2446	2443	2440	2437	2434	2431	2428	2425	2422	2420	2417	4	7
	50	2435	2432	2429	2426	2423	2420	2417	2414	2411	2408	2406	2403	5	6
55	0	2421	2418	2415	2412	2409	2406	2403	2400	2397	2394	2392	2389	6	5
	10	2407	2404	2401	2398	2395	2392	2389	2386	2383	2380	2378	2375	7	3
	20	2393	2390	2387	2384	2381	2378	2375	2372	2369	2366	2364	2361	8	2
	30	2379	2376	2373	2370	2367	2364	2361	2358	2355	2352	2350	2347	9	0
	40	2365	2362	2359	2356	2353	2350	2347	344	2342	2339	2336	2334		
	50	2351	2348	2345	2342	2339	2336	2333	2330	2328	2325	2322	2320	Sec.	Cor
56	0	2337	2334	2331	2328	2325	2322	2319	2316	2314	2311	2308	2306	0	13
	10	2323	2320	2317	2314	2311	2308	2305	2302	2300	2297	2295	2292	1	12
	20	2310	2307	2304	2301	2298	2295	2292	2289	2287	2284	2281	2279	2	10
	30	2296	2293	2290	2287	2284	2281	2278	2275	2273	2270	2267	2265	3	9
	40	2282	2279	2276	2273	2270	2267	2264	2261	2259	2256	2254	2251	4	8
	50	2269	2265	2262	2259	2257	2254	2251	2248	2246	2243	2240	2238	5	6
57	0	2255	2252	2249	2246	2243	2240	2237	2234	2232	2229	2227	2224	6	5
	10	2241	2238	2235	2232	2230	2227	2224	2221	2219	2216	2213	2211	7	3
	20	2228	2225	2222	2219	2216	2213	2210	2207	2205	2203	2200	2198	8	2
	30	2214	2211	2208	2205	2203	2200	2197	2194	2192	2189	2187	2184	9	1
	40	2201	2198	2195	2192	2190	2187	2184	2181	2179	2176	2173	2171		
	50	2188	2185	2182	2179	2176	2173	2170	2167	2165	2162	2160	2157	Sec.	Cor.
58	0	2174	2171	2168	2165	2163	2160	2157	2154	2152	2149	2147	2144	0	13
	10	2161	2158	2155	2152	2150	2147	2144	2141	2139	2136	2134	2131	1	12
	20	2148	2145	2142	2139	2137	2134	2131	2128	2126	2123	2121	2118	2	10
	30	2135	2132	2129	2126	2123	2120	2117	2114	2112	2110	2108	2105	3	9
	40	2121	2119	2116	2113	2110	2107	2104	2101	2099	2097	2094	2092	4	8
	50	2108	2106	2103	2100	2097	2094	2091	2088	2086	2084	2081	2079	5	6
59	0	2095	2092	2089	2086	2084	2081	2078	2075	2073	2071	2068	2066	6	5
	10	2082	2079	2076	2073	2071	2068	2065	2062	2060	2058	2055	2053	7	4
	20	2069	2066	2063	2060	2058	2055	2052	2049	2047	2045	2042	2040	8	3
	30	2056	2053	2050	2047	2045	2042	2039	2036	2034	2032	2030	2027	9	1
	40	2043	2041	2038	2035	2032	2029	2026	2023	2021	2019	2017	2014		
	50	2030	2028	2025	2022	2020	2017	2014	2011	2009	2006	2004	2001	Sec.	Cor
60	0	2017	2015	2012	2009	2007	2004	2001	1998	1996	1993	1991	1988	0	13
	10	2005	2002	1999	1996	1994	1991	1988	1985	1983	1981	1979	1976	1	12
	20	1992	1989	1986	1983	1981	1978	1975	1972	1970	1968	1966	1963	2	10
	30	1979	1977	1974	197	1969	1966	1963	1960	1958	1955	1953	1950	3	9
	40	1966	1964	1961	1956	1956	1953	1950	1947	1945	1942	1940	1937	4	8
	50	1954	1951	1948	1945	1943	1940	1937	1934	1932	1930	1928	1925	5	7
61	0	1941	1939	1936	1933	1931	1928	1925	1922	1920	1917	1915	1912	6	5
	10	1928	1926	1923	1920	1918	1915	1912	1909	1907	1905	1902	1900	7	4
	20	1916	1914	1911	1908	1906	1903	1900	1897	1895	1892	1890	1887	8	3
	30	1903	1901	1898	1895	1893	1890	1887	1885	1883	1880	1878	1875	9	2

Digitized by Google

TABLE XIX. Correction.

App. Alt. of ☽'s cen. D.	M.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′
17	0	10.11	9.14	8.17	7.19	6.22	5.24	4.27	3.30
	10	10.12	9.15	8.18	7.20	6.23	5.26	4.28	3.31
	20	10.13	9.16	8.19	7.21	6.24	5.27	4.30	3.32
	30	10.14	9.17	8.20	7.23	6.25	5.28	4.31	3.34
	40	10.15	9.18	8.21	7.24	6.27	5.29	4.32	3.35
	50	10.16	9.19	8.22	7.25	6.28	5.31	4.34	3.37
18	0	10.18	9.21	8.23	7.26	6.29	5.32	4.35	3.38
	10	10.19	9.22	8.25	7.28	6.31	5.34	4.37	3.40
	20	10.20	9.23	8.26	7.29	6.32	5.35	4.38	3.41
	30	10.22	9.25	8.28	7.31	6.34	5.37	4.40	3.43
	40	10.23	9.26	8.29	7.32	6.36	5.39	4.42	3.45
	50	10.24	9.28	8.31	7.34	6.37	5.40	4.44	3.47

Table A. Proportional part for Seconds of Parallax. Add.

S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
0	56	55	54	53	52	51	50	49	48	47
10	46	46	45	44	43	42	41	40	39	38
20	37	36	35	34	33	32	31	30	29	28
30	27	26	25	25	24	23	22	21	20	19
40	18	17	16	15	14	13	12	11	10	9
50	8	7	6	5	5	4	3	2	1	0
0	56	55	54	53	52	51	50	49	48	47
10	47	46	45	44	43	42	41	40	39	38
20	37	36	35	34	33	32	31	30	29	28
30	28	27	26	25	24	23	22	21	20	19
40	18	17	16	15	14	13	12	11	10	9
50	9	8	7	6	5	4	3	2	1	0

Table B. For Min. of Alt. Add.

M.	S.	M.	S.
0	0	0	0
1	0	1	0
2	0	2	0
3	0	3	0
4	0	4	0
5	1	5	1
6	1	6	1
7	1	7	1
8	1	8	1
9	1	9	1

TABLE XIX. Logarithms.

☽'s Hor. Parallax. M.	S.	Apparent Altitude of ☽'s centre. 17° 0′	17° 10′	17° 20′	17° 30′	17° 40′	17° 50′	18° 0′	18° 10′	18° 20′	18° 30′	18° 40′	18° 50′	Table C. Cor. Sec. of Par. Add. Sec.	Cor.
54	0	2471	2469	2466	2464	2462	2459	2457	2455	2452	2450	2448	2446	0	13
	10	2457	2454	2452	2449	2447	2444	2442	2440	2438	2436	2434	2431	1	12
	20	2443	2440	2438	2435	2433	2430	2428	2426	2424	2422	2420	2417	2	10
	30	2429	2426	2424	2421	2419	2416	2414	2412	2410	2408	2406	2403	3	9
	40	2415	2412	2410	2407	2405	2402	2400	2398	2396	2394	2392	2389	4	7
	50	2401	2398	2396	2393	2391	2388	2386	2384	2382	2380	2378	2375	5	6
55	0	2387	2384	2382	2379	2377	2374	2372	2370	2368	2366	2364	2361	6	5
	10	2373	2370	2368	2365	2363	2360	2358	2356	2354	2352	2350	2348	7	3
	20	2359	2356	2354	2351	2349	2346	2344	2342	2340	2338	2336	2334	8	2
	30	2345	2342	2340	2337	2335	2333	2331	2329	2326	2324	2322	2320	9	0
	40	2331	2329	2326	2324	2322	2319	2317	2315	2312	2310	2308	2306		
	50	2317	2315	2312	2310	2308	2305	2303	2301	2299	2297	2295	2293	Sec.	Cor.
56	0	2303	2301	2298	2296	2294	2291	2289	2287	2285	2283	2281	2279	0	13
	10	2290	2287	2285	2282	2280	2278	2276	2274	2271	2269	2267	2265	1	12
	20	2276	2274	2271	2269	2267	2264	2262	2260	2258	2256	2254	2252	2	10
	30	2262	2260	2257	2255	2253	2250	2248	2246	2244	2242	2240	2238	3	9
	40	2249	2247	2244	2242	2240	2237	2235	2233	2231	2229	2227	2225	4	8
	50	2235	2233	2230	2228	2226	2223	2221	2219	2217	2215	2213	2211	5	6
57	0	2222	2220	2217	2215	2213	2210	2208	2206	2204	2202	2200	2198	6	5
	10	2208	2206	2203	2201	2199	2197	2195	2193	2190	2188	2186	2185	7	3
	20	2195	2193	2190	2188	2186	2183	2181	2179	2177	2175	2173	2171	8	2
	30	2182	2180	2177	2175	2173	2170	2168	2166	2164	2162	2160	2158	9	1
	40	2168	2166	2163	2161	2159	2157	2155	2153	2151	2149	2147	2145		
	50	2155	2153	2150	2148	2146	2143	2141	2139	2137	2135	2133	2131	Sec.	Cor.
58	0	2142	2140	2137	2135	2133	2130	2128	2126	2124	2122	2120	2118	0	13
	10	2129	2127	2124	2122	2120	2117	2115	2113	2111	2109	2107	2105	1	12
	20	2116	2114	2111	2109	2107	2104	2102	2100	2098	2096	2094	2092	2	10
	30	2102	2100	2097	2095	2093	2091	2089	2087	2085	2083	2081	2079	3	9
	40	2089	2087	2084	2082	2080	2078	2076	2074	2072	2070	2068	2066	4	8
	50	2076	2074	2071	2069	2067	2065	2063	2061	2059	2057	2055	2053	5	6
59	0	2063	2061	2058	2056	2054	2052	2050	2048	2046	2044	2042	2040	6	5
	10	2050	2048	2046	2044	2042	2039	2037	2035	2033	2031	2029	2027	7	4
	20	2037	2035	2033	2031	2029	2026	2024	2022	2020	2018	2016	2015	8	3
	30	2025	2023	2020	2018	2016	2013	2011	2009	2007	2005	2003	2002	9	1
	40	2012	2010	2007	2005	2003	2001	1999	1997	1995	1993	1991	1989		
	50	1999	1997	1994	1992	1990	1988	1986	1984	1982	1980	1978	1976	Sec.	Cor.
60	0	1986	1984	1981	1979	1977	1975	1973	1971	1969	1967	1965	1964	0	13
	10	1973	1971	1969	1967	1965	1962	1960	1958	1956	1954	1952	1951	1	12
	20	1961	1959	1956	1954	1952	1950	1948	1946	1944	1942	1940	1938	2	10
	30	1948	1946	1943	1941	1939	1937	1935	1933	1931	1929	1927	1926	3	9
	40	1935	1933	1931	1929	1927	1925	1923	1921	1919	1917	1915	1913	4	8
	50	1923	1921	1918	1916	1914	1912	1910	1908	1906	1904	1902	1901	5	7
61	0	1910	1908	1906	1904	1902	1899	1897	1895	1894	1892	1890	1888	6	5
	10	1898	1896	1893	1891	1889	1887	1885	1883	1881	1879	1877	1876	7	4
	20	1885	1883	1881	1879	1877	1875	1873	1871	1869	1867	1865	1863	8	3
	30	1873	1871	1868	1866	1864	1862	1860	1858	1856	1854	1852	1851	9	2

Digitized by Google

TABLE XIX. Correction.

App. Alt. D's cen.		D's Horizontal Parallax.								Table A. Proportional part for Seconds of Parallax. Add.										
D.	M.	54′	55′	56′	57′	58′	59′	60′	61′	S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
19	0	10.26	9.29	8.32	7.36	6.39	5.42	4.46	3.49	0	56	55	54	53	52	51	50	49	48	48
	10	10.28	9.31	8.34	7.37	6.41	5.44	4.47	3.51	10	47	46	45	44	43	42	41	40	39	38
	20	10.29	9.33	8.36	7.39	6.43	5.46	4.49	3.53	20	37	36	35	34	33	32	31	31	30	29
	30	10.31	9.34	8.38	7.41	6.45	5.48	4.51	3.55	30	28	27	26	25	24	23	22	21	20	19
	40	10.33	9.36	8.39	7.43	6.46	5.50	4.53	3.57	40	18	17	16	15	14	14	13	12	11	10
	50	10.34	9.38	8.41	7.45	6.48	5.52	4.56	3.59	50	9	8	7	6	5	4	3	2	1	0
20	0	10.37	9.41	8.44	7.48	6.51	5.55	4.59	4. 2	0	55	54	53	52	51	50	49	48	47	47
	10	10.39	9.43	8.46	7.50	6.54	5.57	5. 1	4. 5	10	46	45	44	43	42	41	40	39	38	37
	20	10.41	9.45	8.48	7.52	6.56	5.59	5. 3	4. 7	20	36	35	34	33	33	32	31	30	29	28
	30	10.43	9.47	8.50	7.54	6.58	6. 2	5. 5	4. 9	30	27	26	25	24	23	22	21	20	19	18
	40	10.45	9.49	8.52	7.56	7. 0	6. 4	5. 8	4.12	40	17	17	16	15	14	13	12	11	10	9
	50	10.47	9.51	8.55	7.59	7. 2	6. 6	5.10	4.14	50	8	7	6	5	4	3	2	2	1	0

Table B. For Min. of Alt. Add.

M.	S.	M.	S.
0	0	0	0
1	0	1	0
2	0	2	0
3	0	3	1
4	1	4	1
5	1	5	1
6	1	6	1
7	1	7	2
8	1	8	2
9	2	9	2

TABLE XIX. Logarithms.

D's Hor. Parallax.		Apparent Altitude of D's Centre.												Table C. Cor. Sec. of Par. Add.	
M.	S.	19° 0′	19° 10′	19° 20′	19° 30′	19° 40′	19° 50′	20° 0′	20° 10′	20° 20′	20° 30′	20° 40′	20° 50′	Sec	Cor.
54	0	2445	2443	2441	2439	2437	2435	2433	2431	2429	2427	2426	2424	0	12
	10	2430	2428	2427	2425	2423	2421	2419	2417	2415	2413	2412	2410	1	11
	20	2416	2414	2412	2410	2408	2407	2405	2403	2401	2399	2398	2396	2	9
	30	2402	2400	2398	2396	2394	2393	2391	2389	2387	2385	2384	2382	3	8
	40	2388	2386	2384	2382	2380	2379	2377	2375	2373	2371	2370	2368	4	6
	50	2374	2372	2370	2368	2366	2365	2363	2361	2359	2357	2356	2354	5	5
55	0	2360	2358	2357	2355	2353	2351	2349	2347	2346	2344	2342	2341	6	4
	10	2347	2345	2343	2341	2339	2337	2335	2333	2332	2330	2328	2327	7	2
	20	2333	2331	2329	2327	2325	2323	2321	2319	2318	2316	2314	2313	8	1
	30	2319	2317	2315	2313	2311	2310	2308	2306	2304	2302	2301	2299	9	0
	40	2305	2303	2301	2299	2297	2296	2294	2292	2291	2289	2287	2286		
	50	2292	2290	2288	2286	2284	2282	2280	2278	2277	2275	2273	2272	Sec	Cor.
56	0	2278	2276	2274	2272	2270	2269	2267	2265	2264	2262	2260	2259	0	12
	10	2264	2262	2261	2259	2257	2255	2253	2251	2250	2248	2246	2245	1	11
	20	2251	2249	2247	2245	2243	2242	2240	2238	2236	2234	2233	2231	2	9
	30	2237	2235	2233	2231	2229	2228	2226	2224	2223	2221	2219	2218	3	8
	40	2224	2222	2220	2218	2216	2215	2213	2211	2210	2208	2206	2205	4	7
	50	2210	2208	2207	2205	2203	2201	2199	2197	2196	2194	2192	2191	5	5
57	0	2197	2195	2193	2191	2189	2188	2186	2184	2183	2181	2179	2178	6	4
	10	2184	2182	2180	2178	2176	2175	2173	2171	2170	2168	2166	2165	7	3
	20	2170	2168	2167	2165	2163	2161	2159	2157	2156	2154	2152	2151	8	1
	30	2157	2155	2153	2151	2149	2148	2146	2144	2143	2141	2139	2138	9	0
	40	2144	2142	2140	2138	2136	2135	2133	2131	2130	2128	2126	2125		
	50	2130	2128	2127	2125	2123	2122	2120	2118	2117	2115	2113	2112	Sec	Cor.
58	0	2117	2115	2114	2112	2110	2109	2107	2105	2104	2102	2100	2099	0	12
	10	2104	2102	2101	2099	2097	2095	2093	2091	2090	2088	2087	2086	1	11
	20	2091	2089	2088	2086	2084	2082	2080	2078	2077	2075	2074	2073	2	9
	30	2078	2076	2075	2073	2071	2069	2067	2065	2064	2062	2061	2060	3	8
	40	2065	2063	2062	2060	2058	2056	2054	2052	2051	2049	2048	2047	4	7
	50	2052	2050	2049	2047	2045	2043	2041	2039	2038	2036	2035	2034	5	6
59	0	2039	2037	2036	2034	2032	2031	2029	2027	2026	2024	2022	2021	6	4
	10	2026	2024	2023	2021	2019	2018	2016	2014	2013	2011	2009	2008	7	3
	20	2014	2012	2010	2008	2006	2005	2003	2001	2000	1998	1996	1995	8	2
	30	2001	1999	1997	1995	1993	1992	1990	1988	1987	1985	1984	1983	9	0
	40	1988	1986	1985	1983	1981	1979	1977	1975	1974	1972	1971	1970		
	50	1975	1973	1972	1970	1968	1967	1965	1963	1962	1960	1958	1957	Sec	Cor
60	0	1963	1961	1959	1957	1955	1954	1952	1950	1949	1947	1946	1945	0	12
	10	1950	1948	1946	1944	1942	1941	1939	1937	1936	1934	1933	1932	1	11
	20	1937	1935	1934	1932	1930	1929	1927	1925	1924	1922	1920	1919	2	0
	30	1925	1923	1921	1919	1917	1916	1914	1912	1911	1909	1908	1907	3	8
	40	1912	1910	1909	1907	1905	1904	1902	1900	1899	1897	1895	1894	4	7
	50	1900	1898	1896	1894	1892	1891	1889	1887	1886	1884	1883	1882	5	6
61	0	1887	1885	1884	1882	1880	1879	1877	1875	1874	1872	1871	1870	6	5
	10	1875	1873	1871	1869	1867	1866	1864	1862	1861	1859	1858	1857	7	3
	20	1862	1860	1859	1857	1855	1854	1852	1850	1849	1847	1846	1845	8	2
	30	1850	1848	1847	1845	1843	1842	1840	1838	1837	1835	1834	1833	9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt. ☽'s cen.		☽'s Horizontal Parallax.								Table A. Proportional part for Seconds of Parallax. Add.										
D.	M.	54	55′	56′	57′	58′	59′	60′	61′	S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
21	0	10.49	9.53	8.57	8. 1	7. 5	6. 9	5.13	4.17	0	55	54	53	52	51	50	49	48	48	47
	10	10.51	9.55	8.59	8. 3	7. 7	6.11	5.15	4.19	10	46	45	44	43	42	41	40	39	38	37
	20	10.53	9.57	9. 1	8. 6	7.10	6.14	5.18	4.22	20	36	35	35	34	33	32	31	30	29	28
	30	10.55	10. 0	9. 4	8. 8	7.12	6.16	5.20	4.25	30	27	26	25	24	23	22	21	21	20	19
	40	10.58	10. 2	9. 6	8.10	7.15	6.19	5.23	4.27	40	18	17	16	15	14	13	12	11	10	9
	50	11. 0	10. 4	9. 9	8.13	7.17	6.22	5.26	4.30	50	8	8	7	6	5	4	3	2	1	0
22	0	11. 2	10. 7	9.11	8.15	7.20	6.24	5.29	4.33	0	55	54	53	52	51	50	49	49	48	47
	10	11. 5	10. 9	9.14	8.18	7.22	6.27	5.31	4.36	10	46	45	44	43	42	41	40	39	38	37
	20	11. 7	10.12	9.16	8.21	7.25	6.30	5.34	4.39	20	37	36	35	34	33	32	31	30	29	28
	30	11.10	10.14	9.19	8.23	7.28	6.32	5.37	4.42	30	27	26	25	25	24	23	22	21	20	19
	40	11.12	10.17	9.21	8.26	7.31	6.35	5.40	4.45	40	18	17	16	15	14	13	13	12	11	10
	50	11.15	10.19	9.24	8.29	7.34	6.38	5.43	4.48	50	9	8	7	6	5	4	3	2	1	0
23	0	11.18	10.23	9.28	8.33	7.37	6.42	5.47	4.52	0	54	53	52	51	50	49	48	48	47	46
	10	11.21	10.26	9.31	8.35	7.40	6.45	5.50	4.55	10	45	44	43	42	41	40	39	38	37	37
	20	11.24	10.29	9.33	8.38	7.43	6.48	5.53	4.58	20	36	35	34	33	32	31	30	29	28	27
	30	11.26	10.31	9.36	8.41	7.46	6.51	5.56	5. 1	30	26	26	25	24	23	22	21	20	19	18
	40	11.29	10.34	9.39	8.44	7.49	6.54	5.59	5. 4	40	17	16	15	15	14	13	12	11	10	9
	50	11.32	10.37	9.42	8.47	7.52	6.57	6. 3	5. 8	50	8	7	6	5	4	4	3	2	1	0
24	0	11.35	10.40	9.45	8.50	7.55	7. 1	6. 6	5.11	0	54	53	52	51	50	49	49	48	47	46
	10	11.38	10.43	9.48	8.53	7.59	7. 4	6. 9	5.14	10	45	44	43	42	41	40	39	39	38	37
	20	11.40	10.46	9.51	8.56	8. 2	7. 7	6.12	5.18	20	36	35	34	33	32	31	30	29	29	28
	30	11.43	10.49	9.54	9. 0	8. 5	7.10	6.16	5.21	30	27	26	25	24	23	22	21	20	19	18
	40	11.46	10.52	9.57	9. 3	8. 8	7.14	6.19	5.25	40	18	17	16	15	14	13	12	11	10	9
	50	11.49	10.55	10. 0	9. 6	8.12	7.17	6.23	5.28	50	8	8	7	6	5	4	3	2	1	0

Table B. For Min. of alt. Add.

D.	M.	S.
21	0	0
	1	0
	2	0
	3	1
	4	1
	5	1
	6	1
	7	2
	8	2
	9	2
22	0	0
	1	0
	2	1
	3	1
	4	1
	5	1
	6	2
	7	2
	8	2
	9	2
23	0	0
	1	0
	2	1
	3	1
	4	1
	5	1
	6	2
	7	2
	8	2
	9	3
24	0	0
	1	0
	2	1
	3	1
	4	1
	5	2
	6	2
	7	2
	8	3
	9	3

Explanation of Table XIX.

This table consists of two parts, for finding a *correction* of the moon's distance and a *logarithm* corresponding: they are both in the same page from the beginning of the table to the altitude of 21 degrees, after which the correction is on the left hand page, and the logarithm on the right, both being found at the same opening of the book, in the following manner.

To find the Correction of Table XIX.

1. Enter the table marked *Correction*, and find in the side column the moon's apparent altitude, or the altitude next less, if there be any units of miles in the altitude; opposite to this, and under the minutes of the moon's horizontal parallax, will be the approximate correction.

2. Enter table A, abreast of the approximate correction, and find the seconds of the moon's horizontal parallax, viz. the tens of seconds at the side, and the units at the top, under the latter, and opposite the former will be the correction of table A.

3. Enter table B, abreast of the approximate correction, and find the units of miles in the moon's apparent altitude (neglected above), opposite to which will be a number of seconds. which, being added to the corrections found from table XIX. and from table A, will give the sought correction.

To find the Logarithm of Table XIX.

Enter the table marked *Logarithms*, in the column titled at the top with the degrees and minutes *nearest* to the moon's apparent altitude, and find the logarithm corresponding to the moon's horizontal parallax in the side column, or the next less parallax, if there be units of seconds in it. Abreast of this in the table C, opposite the units of seconds of parallax neglected, will be a correction to be added to the former logarithm, to obtain the logarithm sought.

It was observed in a former part of his work, that in fixing these tables so as to render the corrections of the tables A, B, C, additive, it had been found necessary to make the greatest corrections correspond to 0″ of parallax and 0′ of altitude, so that *when you find the exact parallax and altitude in the side and top columns of table XIX. it will still be necessary to refer to the tables A, B, or C, to take out the corrections corresponding to 0″ of parallax or 0′ of altitude.* This is evident from the inspection of the tables, but it was proper to make this remark as a caution to prevent mistakes. To illustrate these rules, the following examples are given, in which all the corrections are put down and added together; but after a little practice it will be very easy to take the numbers from the table by inspection and add them together without the trouble of writing them down separately.

Digitized by Google

TABLE XIX.

Logarithms.

☽'s Hor. Parallax. M.	S.	Apparent Altitude of ☽'s centre 21° 0'	21° 20'	21° 40'	22° 0'	22° 20'	22° 40'	23° 0'	23° 20'	23° 40'	24° 0'	24° 20'	24° 40'	Table C. Cor. Sec. of Par. Add. Sec.	Cor.
54	0	2422	2419	2416	2413	2410	2407	2404	2401	2399	2396	2394	2391	0	12
	10	2408	2405	2402	2399	2396	2393	2390	2387	2385	2382	2380	2377	1	11
	20	2394	2391	2388	2385	2382	2379	2376	2373	2371	2368	2366	2363	2	9
	30	2380	2377	2374	2371	2368	2365	2362	2360	2357	2355	2352	2350	3	8
	40	2366	2363	2360	2357	2354	2352	2349	2346	2344	2341	2339	2336	4	6
	50	2352	2349	2346	2343	2340	2338	2335	2332	2330	2327	2325	2322	5	5
55	0	2339	2335	2332	2329	2326	2324	2321	2318	2316	2313	2311	2308	6	4
	10	2325	2322	2319	2316	2313	2310	2307	2304	2302	2299	2297	2294	7	2
	20	2311	2308	2305	2302	2299	2296	2293	2291	2288	2286	2284	2281	8	1
	30	2297	2294	2291	2288	2285	2283	2280	2277	2275	2272	2270	2267	9	0
	40	2284	2281	2278	2275	2272	2269	2266	2263	2261	2258	2256	2253		
	50	2270	2267	2264	2261	2258	2256	2253	2250	2248	2245	2243	2240	Sec.	Cor.
56	0	2257	2253	2250	2247	2244	2242	2239	2236	2234	2231	2229	2226	0	12
	10	2243	2240	2237	2234	2231	2229	2226	2223	2221	2218	2216	2213	1	11
	20	2229	2226	2223	2220	2217	2215	2212	2210	2207	2205	2203	2200	2	9
	30	2216	2213	2210	2207	2204	2202	2199	2196	2194	2191	2189	2186	3	8
	40	2203	2200	2197	2194	2191	2188	2185	2183	2180	2178	2176	2173	4	7
	50	2189	2186	2183	2180	2177	2175	2172	2170	2167	2165	2163	2160	5	5
57	0	2176	2173	2170	2167	2164	2162	2159	2156	2154	2151	2149	2146	6	4
	10	2163	2160	2157	2154	2151	2149	2146	2143	2141	2138	2136	2133	7	3
	20	2149	2146	2144	2141	2138	2135	2132	2130	2128	2125	2123	2120	8	1
	30	2136	2133	2130	2127	2124	2122	2119	2117	2115	2112	2110	2107	9	0
	40	2123	2120	2117	2114	2111	2109	2106	2104	2101	2099	2097	2094		
	50	2110	2107	2104	2101	2098	2096	2093	2091	2088	2086	2084	2081	Sec.	Cor.
58	0	2097	2094	2091	2088	2085	2083	2080	2078	2075	2073	2071	2068	0	12
	10	2084	2081	2078	2075	2072	2070	2067	2065	2062	2060	2058	2055	1	11
	20	2071	2068	2065	2062	2059	2057	2054	2052	2049	2047	2045	2042	2	9
	30	2058	2055	2052	2049	2046	2044	2041	2039	2036	2034	2032	2029	3	8
	40	2045	2042	2039	2036	2033	2031	2028	2026	2023	2021	2019	2016	4	7
	50	2032	2029	2026	2023	2020	2018	2015	2013	2010	2008	2006	2003	5	6
59	0	2019	2016	2013	2010	2008	2006	2003	2000	1998	1995	1993	1991	6	4
	10	2006	2003	2001	1998	1995	1993	1990	1987	1985	1982	1980	1978	7	3
	20	1993	1990	1988	1985	1982	1980	1977	1975	1972	1970	1968	1965	8	2
	30	1981	1978	1975	1972	1969	1967	1964	1962	1959	1957	1955	1953	9	0
	40	1968	1965	1962	1959	1957	1954	1952	1949	1947	1944	1942	1940		
	50	1955	1952	1950	1947	1944	1942	1939	1937	1934	1932	1930	1927	Sec.	Cor.
60	0	1943	1940	1937	1934	1931	1929	1926	1924	1921	1919	1917	1915	0	12
	10	1930	1927	1925	1922	1919	1917	1914	1912	1909	1907	1905	1902	1	11
	20	1917	1914	1912	1909	1906	1904	1901	1899	1896	1894	1892	1890	2	10
	30	1905	1902	1900	1897	1894	1892	1889	1887	1884	1882	1880	1877	3	8
	40	1892	1889	1887	1884	1881	1879	1876	1874	1871	1869	1867	1865	4	7
	50	1880	1877	1875	1872	1869	1867	1864	1862	1859	1857	1855	1853	5	6
61	0	1868	1865	1862	1859	1857	1854	1852	1850	1847	1845	1843	1840	6	5
	10	1855	1852	1850	1847	1844	1842	1839	1837	1834	1832	1830	1828	7	3
	20	1843	1840	1838	1835	1832	1830	1827	1825	1822	1820	1818	1816	8	2
	30	1831	1828	1825	1822	1820	1817	1815	1813	1810	1806	1806	1803	9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt. D.	☽'s cor. M.	☽'s Horizontal Parallax 54	55′	56′	57′	58′	59′	60′	61′	Table A. Proportional part for Seconds of Parallax. Add. S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
25	0	11.53	10.59	10. 5	9.10	8.16	7.22	6.27	5.33	0	53	52	51	50	49	48	48	47	46	45
	10	11.57	11. 2	10. 8	9.14	8.19	7.25	6.31	5.36	10	44	43	42	41	40	39	39	38	37	36
	20	12. 0	11. 5	10.11	9.17	8.23	7.28	6.34	5.40	20	35	34	33	32	31	30	30	29	28	27
	30	12. 3	11. 9	10.15	9.20	8.26	7.32	6.38	5.44	30	26	25	24	23	22	21	20	20	19	18
	40	12. 6	11.12	10.18	9.24	8.30	7.36	6.41	5.47	40	17	16	15	14	13	12	11	11	10	9
	50	12. 9	11.15	10.21	9.27	8.33	7.39	6.45	5.51	50	8	7	6	5	4	3	2	1	1	0
26	0	12.13	11.19	10.25	9.31	8.37	7.43	6.49	5.55	0	53	52	51	50	49	49	48	47	46	45
	10	12.16	11.22	10.28	9.34	8.40	7.47	6.53	5.59	10	44	43	42	41	40	40	39	38	37	36
	20	12. 9	11.25	10.32	9.38	8.44	7.50	6.56	6. 3	20	35	34	33	32	32	31	30	29	28	27
	30	12.23	11.29	10.35	9.41	8.48	7.54	7. 0	6. 7	30	26	25	24	23	23	22	21	20	19	18
	40	12.26	11.32	10.39	9.45	8.51	7.58	7. 4	6.11	40	17	16	15	14	14	13	12	11	10	9
	50	12.29	11.36	10.42	9.49	8.55	8. 2	7. 8	6.15	50	8	7	6	6	5	4	3	2	1	0
27	0	12.34	11.40	10.47	9.53	9. 0	8. 6	7.13	6.20	0	52	51	50	49	48	48	47	46	45	44
	10	12.37	11.44	10.51	9.57	9. 4	8.10	7.17	6.24	10	43	42	41	40	40	39	38	37	36	35
	20	12.41	11.48	10.54	10. 1	9. 8	8.14	7.21	6.28	20	34	33	33	32	31	30	29	28	27	26
	30	12.44	11.51	10.58	10. 5	9.11	8.18	7.25	6.32	30	25	24	24	23	22	21	20	19	18	17
	40	12.48	11.55	11. 2	10. 9	9.15	8.22	7.29	6.36	40	17	16	15	14	13	12	11	10	9	9
	50	12.52	11.59	11. 5	10.12	9.19	8.26	7.33	6.40	50	8	7	6	5	4	3	2	1	1	0
28	0	12.55	12. 2	11. 9	10.16	9.23	8.30	7.37	6.44	0	52	51	50	49	48	48	47	46	45	44
	10	12.59	12. 6	11.13	10.20	9.27	8.34	7.42	6.49	10	43	42	41	41	40	39	38	37	36	35
	20	13. 3	12.10	11.17	10.24	9.31	8.39	7.46	6.53	20	34	34	33	32	31	30	29	28	27	26
	30	13. 6	12.14	11.21	10.28	9.36	8.43	7.50	6.57	30	26	25	24	23	22	21	20	19	19	18
	40	13.10	12.18	11.25	10.32	9.40	8.47	7.54	7. 2	40	17	16	15	14	13	12	12	11	10	9
	50	13.14	12.22	11.29	10.36	9.44	8.51	7.59	7. 6	50	8	7	6	5	5	4	3	2	1	0
29	0	13.19	12.26	11.34	10.42	9.49	8.57	8. 4	7.12	0	51	50	49	48	48	47	46	45	44	43
	10	13.23	12.30	11.38	10.46	9.53	9. 1	8. 8	7.16	10	42	41	41	40	39	38	37	36	35	34
	20	13.27	12.34	11.42	10.50	9.57	9. 5	8.13	7.21	20	34	33	32	31	30	29	28	27	27	26
	30	13.31	12.38	11.46	10.54	10. 2	9.10	8.17	7.25	30	25	24	23	22	21	21	20	19	18	17
	40	13.35	12.43	11.50	10.58	10. 6	9.14	8.22	7.30	40	16	15	14	14	13	12	11	10	9	8
	50	13.39	12.47	11.55	11. 3	10.10	9.18	8.26	7.34	50	7	7	6	5	4	3	2	1	0	0

Table B. For Min. of alt. Add.

M.	S. (25°)	S. (26°)	S. (27°)	S. (28°)	S. (29°)
0	0	0	0	0	0
1	0	0	0	0	0
2	1	1	1	1	1
3	1	1	1	1	1
4	1	1	2	2	2
5	2	2	2	2	2
6	2	2	2	2	3
7	2	3	3	3	3
8	3	3	3	3	3
9	3	3	3	4	4

EXAMPLE I.

Given the moon's apparent altitude 44° 27′, and her horizontal parallax 56′ 55″. Required the correction and logarithm?

For the Correction.

In Tab. xix. to alt. 44° 20′ and par. 56′ is	19′ 54″
.. Tab. A. 55″ parallax..................	3
.. Tab. B. 7′ altitude..................	5
Sought correction	20′ 2″

For the Logarithm.

In Tab. xix. to nearest alt. 44½° and par. 56′ 50″	2088
.. Tab. C. 5″ parallax	5
Sought logarithm......................	2093

EXAMPLE II.

Given the moon's apparent altitude 50° 16′, and horizontal parallax 59′ 0″. Required the correction and logarithm?

For the Correction.

In Tab. xix. to alt. 50° 10′ and par. 59′ is	22′ 3″
.. Tab. A. 0″ parallax	38
.. Tab. B. 6′ altitude..................	4
Sought correction	22′ 45″

For the Logarithm.

In Tab. xix. to alt. 50° and par. 59′ 0″......	1913
.. Tab. C. 0″ parallax	12
Sought logarithm	1925

EXAMPLE III.

Given the moon's apparent altitude 28° 27′, and horizontal parallax 54′ 10″. Required the correction and logarithm?

For the Correction.

In Tab. xix. to alt. 28° 20′ and par. 54′ is	13′ 3″
.. Tab A. 10″ parallax	43
.. Tab. B. 7′ altitude	3
Sought correction	13′ 49″

For the Logarithm.

Tab. xix. to nearest alt. 28° 30′ and par. 54′ 10″	2354
Table C. 0″ parallax	12
Sought logarithm	2366

Digitized by Google

TABLE XIX.

Logarithms.

☽'s Hor. Parallax.		Apparent Altitude of ☽'s Centre.											
M.	S.	25° 0′	25° 20′	25° 40′	26° 0′	26° 20′	26° 40′	27° 0′	27° 30′	28° 0′	28° 30′	29° 0′	29° 30′
54	0	2389	2387	2384	2382	2380	2378	2376	2374	2371	2368	2365	2362
	10	2375	2373	2371	2369	2367	2364	2362	2360	2357	2354	2351	2348
	20	2361	2359	2357	2355	2353	2351	2349	2346	2343	2341	2338	2335
	30	2347	2345	2343	2341	2339	2337	2335	2332	2329	2327	2324	2321
	40	2334	2332	2329	2327	2325	2323	2321	2318	2315	2313	2310	2307
	50	2320	2318	2315	2313	2311	2309	2307	2304	2301	2299	2296	2293
55	0	2306	2304	2301	2299	2297	2295	2293	2291	2288	2286	2283	2280
	10	2292	2290	2288	2286	2284	2282	2280	2277	2274	2272	2269	2266
	20	2279	2277	2274	2272	2270	2268	2266	2264	2261	2258	2255	2253
	30	2265	2263	2261	2259	2257	2255	2253	2250	2247	2245	2242	2239
	40	2251	2249	2247	2245	2243	2241	2239	2236	2233	2231	2228	2226
	50	2238	2236	2234	2232	2230	2228	2226	2223	2220	2218	2215	2213
56	0	2224	2222	2220	2218	2216	2214	2212	2210	2207	2205	2202	2199
	10	2211	2209	2207	2205	2203	2201	2199	2196	2193	2191	2188	2185
	20	2198	2196	2193	2191	2189	2187	2185	2183	2180	2178	2175	2172
	30	2184	2182	2180	2178	2176	2174	2172	2170	2167	2165	2162	2159
	40	2171	2169	2167	2165	2163	2161	2159	2156	2153	2151	2148	2146
	50	2158	2156	2153	2151	2149	2147	2146	2143	2140	2138	2135	2132
57	0	2144	2142	2140	2138	2136	2134	2132	2130	2127	2125	2122	2119
	10	2131	2129	2127	2125	2123	2121	2119	2117	2114	2112	2109	2106
	20	2118	2116	2114	2112	2110	2108	2106	2104	2101	2099	2096	2093
	30	2105	2103	2101	2099	2097	2095	2093	2091	2088	2086	2083	2080
	40	2092	2090	2088	2086	2084	2082	2080	2078	2075	2073	2070	2067
	50	2079	2077	2075	2073	2071	2069	2067	2065	2062	2059	2057	2054
58	0	2066	2064	2062	2060	2058	2056	2054	2052	2049	2046	2044	2041
	10	2053	2051	2049	2047	2045	2043	2041	2039	2036	2033	2031	2028
	20	2040	2038	2036	2034	2032	2030	2028	2026	2023	2020	2018	2015
	30	2027	2025	2023	2021	2019	2017	2015	2013	2010	2007	2005	2003
	40	2014	2012	2010	2008	2006	2005	2003	2000	1997	1994	1992	1990
	50	2001	1999	1997	1995	1993	1992	1990	1987	1984	1982	1980	1977
59	0	1989	1987	1985	1983	1981	1979	1977	1975	1972	1969	1967	1964
	10	1976	1974	1972	1970	1968	1966	1964	1962	1959	1956	1954	1952
	20	1963	1961	1959	1957	1955	1954	1952	1949	1946	1944	1942	1939
	30	1951	1949	1947	1945	1943	1941	1939	1937	1934	1931	1929	1927
	40	1938	1936	1934	1932	1930	1928	1926	1924	1921	1918	1916	1914
	50	1925	1923	1921	1919	1917	1916	1914	1912	1909	1906	1904	1902
60	0	1913	1911	1909	1907	1905	1903	1901	1899	1896	1893	1891	1889
	10	1900	1898	1896	1894	1892	1891	1889	1887	1884	1881	1879	1877
	20	1888	1886	1884	1882	1880	1878	1876	1874	1871	1869	1867	1864
	30	1875	1873	1871	1869	1867	1866	1864	1862	1859	1856	1854	1852
	40	1863	1861	1859	1857	1855	1854	1852	1849	1846	1844	1842	1839
	50	1851	1849	1847	1845	1843	1841	1839	1837	1834	1832	1830	1827
61	0	1838	1836	1834	1832	1830	1829	1827	1825	1822	1819	1817	1815
	10	1826	1824	1822	1820	1818	1817	1815	1813	1810	1807	1805	1803
	20	1814	1812	1810	1808	1806	1805	1803	1800	1797	1795	1793	1791
	30	1801	1799	1798	1796	1794	1792	1790	1788	1785	1783	1781	1778

TABLE C. Cor. Sec. of Par. Add.

Sec.	Cor.
0	12
1	11
2	9
3	8
4	6
5	5
6	4
7	2
8	1
9	0
Sec.	Cor.
0	12
1	11
2	9
3	8
4	7
5	5
6	4
7	3
8	1
9	0
Sec.	Cor.
0	12
1	11
2	9
3	8
4	7
5	6
6	4
7	3
8	2
9	0
Sec.	Cor.
0	12
1	11
2	10
3	8
4	7
5	6
6	5
7	3
8	2
9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt. ☽'s cen. D.	M.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Table A. Proportional part for Seconds of Parallax. Add. S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
30	0	13.43	12.51	11.59	11. 7	10.15	9.23	8.31	7.39	0	51	50	49	48	48	47	46	45	44	43
	10	13.47	12.55	12. 3	11.11	10.19	9.27	8.35	7.44	10	42	42	41	40	39	38	37	36	35	35
	20	13.51	12.59	12. 7	11.16	10.24	9.32	8.40	7.48	20	34	33	32	31	30	29	29	28	27	26
	30	13.55	13. 3	12.12	11.20	10.29	9.37	8.45	7.53	30	25	24	23	23	22	21	20	19	18	17
	40	13.59	13. 8	12.16	11.24	10.33	9.41	8.49	7.58	40	17	16	15	14	13	12	11	10	10	9
	50	14. 3	13.12	12.20	11.29	10.37	9.46	8.54	8. 3	50	8	7	6	5	4	4	3	2	1	0
31	0	14. 9	13.17	12.26	11.34	10.43	9.51	9. 0	8. 9	0	50	49	48	47	47	46	45	44	43	42
	10	14.13	13.22	12.30	11.39	10.47	9.56	9. 5	8.13	10	41	41	40	39	38	37	36	35	35	34
	20	14.17	13.26	12.35	11.43	10.52	10. 1	9.10	8.18	20	33	32	31	30	30	29	28	27	26	25
	30	14.21	13.30	12.39	11.48	10.57	10. 6	9.14	8.23	30	24	24	23	22	21	20	19	18	18	17
	40	14.26	13.35	12.44	11.53	11. 2	10.10	9.19	8.28	40	16	15	14	13	12	12	11	10	9	8
	50	14.30	13.39	12.48	11.57	11. 6	10.15	9.24	8.33	50	7	6	6	5	4	3	2	1	0	0
32	0	14.35	13.44	12.53	12. 2	11.11	10.20	9.29	8.38	0	50	49	48	47	47	46	45	44	43	42
	10	14.39	13.48	12.57	12. 7	11.16	10.25	9.34	8.43	10	42	41	40	39	38	37	36	36	35	34
	20	14.43	13.53	13. 2	12.11	11.21	10.30	9.39	8.48	20	33	32	31	31	30	29	28	27	26	26
	30	14.48	13.57	13. 7	12.16	11.25	10.35	9.44	8.54	30	25	24	23	22	21	20	20	19	18	17
	40	14.52	14. 2	13.11	12.21	11.30	10.40	9.49	8.59	40	16	15	15	14	13	12	11	10	9	9
	50	14.57	14. 7	13.16	12.26	11.35	10.45	9.54	9. 4	50	8	7	6	5	4	4	3	2	1	0
33	0	15. 2	14.12	13.22	12.31	11.41	10.51	10. 1	9.10	0	49	48	47	46	46	45	44	43	42	41
	10	15. 7	14.17	13.27	12.36	11.46	10.56	10. 6	9.15	10	41	40	39	38	37	36	36	35	34	33
	20	15.12	14.22	13.31	12.41	11.51	11. 1	10.11	9.21	20	32	31	31	30	29	28	27	26	26	25
	30	15.16	14.26	13.36	12.46	11.56	11. 6	10.16	9.26	30	24	23	22	21	21	20	19	18	17	16
	40	15.21	14.31	13.41	12.51	12. 1	11.11	10.21	9.31	40	16	15	14	13	12	11	11	10	9	8
	50	15.26	14.36	13.46	12.56	12. 6	11.17	10.27	9.37	50	7	6	6	5	4	3	2	1	1	0
34	0	15.31	14.41	13.51	13. 1	12.11	11.22	10.32	9.42	0	49	48	47	47	46	45	44	43	42	42
	10	15.35	14.46	13.56	13. 6	12.17	11.27	10.37	9.48	10	41	40	39	38	37	37	36	35	34	33
	20	15.40	14.50	14. 1	13.11	12.22	11.32	10.43	9.53	20	32	32	31	30	29	28	28	27	26	25
	30	15.45	14.55	14. 6	13.16	12.27	11.38	10.48	9.59	30	24	23	23	22	21	20	19	18	18	17
	40	15.50	15. 0	14.11	13.22	12.32	11.43	10.54	10. 4	40	16	15	14	14	13	12	11	10	9	9
	50	15.55	15. 5	14.16	13.27	12.38	11.48	10.59	10.10	50	8	7	6	5	4	4	3	2	1	0
35	0	16. 0	15.11	14.22	13.33	12.44	11.55	11. 5	10.16	0	48	47	46	46	45	44	43	42	41	41
	10	16. 5	15.16	14.27	13.38	12.49	12. 0	11.11	10.22	10	40	39	38	37	37	36	35	34	33	33
	20	16.10	15.21	14.32	13.43	12.54	12. 6	11.17	10.28	20	32	31	30	29	28	28	27	26	25	24
	30	16.15	15.26	14.38	13.49	13. 0	12.11	11.22	10.33	30	24	23	22	21	20	19	19	18	17	16
	40	16.20	15.32	14.43	13.54	13. 5	12.17	11.28	10.39	40	15	15	14	13	12	11	11	10	9	8
	50	16.25	15.37	14.48	13.59	13.11	12.22	11.33	10.45	50	7	6	6	5	4	3	2	2	1	0

Tab. B. For M. of alt. Add.

D.	M.	S.
30	0	0
	1	0
	2	1
	3	1
	4	2
	5	2
	6	3
	7	3
	8	4
	9	4
31	0	0
	1	0
	2	1
	3	1
	4	2
	5	2
	6	3
	7	3
	8	4
	9	4
32	0	0
	1	0
	2	1
	3	1
	4	2
	5	2
	6	3
	7	3
	8	4
	9	4
33	0	0
	1	0
	2	1
	3	1
	4	2
	5	2
	6	3
	7	3
	8	4
	9	4
34	0	0
	1	1
	2	1
	3	2
	4	2
	5	3
	6	3
	7	4
	8	4
	9	5
35	0	0
	1	1
	2	1
	3	2
	4	2
	5	3
	6	3
	7	4
	8	4
	9	5

EXAMPLE IV.

Given the moon's apparent altitude 76° 36′, and her horizontal parallax 56′ 18″. Required the correction and logarithm?

For the Correction.

In Tab. xix. to alt. 76° 30′ and par. 56′ is	46′ 37″
.. Tab. A. 18″ parallax..................	10
.. Tab. B. 6′ altitude..................	6
Sought correction	46′ 53″

For the Logarithm.

In Tab. xix. to nearest alt. 77° and par. 56′ 10″	2110
.. Tab. C. 8 parallax	2
Sought logarithm..................	2112

EXAMPLE V.

Given the moon's apparent altitude 16° 25′, and her horizontal parallax 58′ 45′. Required the correction and logarithm?

For the Correction.

In Tab. xix. to alt. 16° 20′ and par. 58′ is	6′ 17″
.. Tab. A. 45″ parallax..................	14
.. Tab. B. 5′ altitude	0
Sought correction	6′ 31″

For the Logarithm.

Tab. xix. to nearest alt. 16° 20′ and par. 58′ 40″ is	2099
Tab. C. 5″ parallax	6
Sought logarithm	2105

Digitized by Google

TABLE XIX.

Logarithms.

☽'s Hor. Parallax.		Apparent Altitude of ☽'s centre.												Table C. Cor. Sec. of Par. Add.	
M.	S.	30°	30½°	31°	31½°	32°	32½°	33°	33½°	34°	34½°	35°	35½°	Sec.	Cor.
54	0	2360	2358	2356	2354	2352	2349	2347	2345	2344	2342	2340	2338	0	12
	10	2346	2344	2342	2340	2338	2336	2334	2332	2330	2328	2326	2324	1	11
	20	2333	2330	2328	2326	2324	2322	2320	2318	2316	2314	2313	2311	2	9
	30	2319	2316	2314	2312	2310	2308	2306	2304	2302	2300	2299	2297	3	8
	40	2305	2302	2300	2298	2296	2294	2292	2290	2289	2287	2285	2283	4	7
	50	2291	2289	2287	2285	2283	2281	2279	2277	2275	2274	2272	2270	5	5
55	0	2278	2275	2273	2271	2269	2267	2265	2263	2262	2260	2258	2256	6	4
	10	2264	2262	2260	2258	2256	2254	2252	2250	2248	2246	2245	2243	7	2
	20	2251	2248	2246	2244	2242	2240	2238	2236	2234	2232	2231	2229	8	1
	30	2237	2235	2233	2231	2229	2227	2225	2223	2221	2219	2218	2216	9	0
	40	2224	2221	2219	2217	2215	2213	2211	2209	2208	2206	2204	2202		
	50	2211	2208	2206	2204	2202	2200	2198	2196	2194	2192	2191	2189	Sec.	Cor.
56	0	2197	2194	2192	2190	2188	2186	2184	2182	2181	2179	2177	2175	0	12
	10	2183	2181	2179	2177	2175	2173	2171	2169	2168	2166	2164	2162	1	11
	20	2170	2168	2166	2164	2162	2160	2158	2156	2154	2152	2151	2149	2	9
	30	2157	2155	2153	2150	2148	2146	2145	2143	2141	2139	2138	2136	3	8
	40	2144	2141	2139	2137	2135	2133	2131	2129	2128	2126	2124	2122	4	7
	50	2130	2128	2126	2124	2122	2120	2118	2116	2115	2113	2111	2109	5	5
57	0	2117	2115	2113	2111	2109	2107	2105	2103	2102	2100	2098	2096	6	4
	10	2104	2102	2100	2098	2096	2094	2092	2090	2089	2087	2085	2083	7	3
	20	2091	2089	2087	2085	2083	2081	2079	2077	2076	2074	2072	2070	8	1
	30	2078	2076	2074	2072	2070	2068	2066	2064	2063	2061	2059	2057	9	0
	40	2065	2063	2061	2059	2057	2055	2053	2051	2050	2048	2046	2044		
	50	2052	2050	2048	2046	2044	2042	2040	2038	2037	2035	2033	2031	Sec.	Cor.
58	0	2039	2037	2035	2033	2031	2029	2027	2025	2024	2022	2020	2018	0	12
	10	2026	2024	2022	2020	2018	2016	2014	2013	2011	2009	2008	2006	1	11
	20	2013	2011	2009	2007	2005	2003	2002	2000	1998	1996	1995	1993	2	9
	30	2001	1998	1996	1994	1993	1991	1989	1987	1985	1983	1982	1980	3	8
	40	1988	1986	1984	1982	1980	1978	1976	1974	1973	1971	1969	1967	4	7
	50	1975	1973	1971	1969	1967	1965	1963	1961	1960	1958	1957	1955	5	6
59	0	1962	1960	1958	1956	1954	1952	1951	1949	1947	1945	1944	1942	6	4
	10	1950	1948	1946	1944	1942	1940	1938	1936	1935	1933	1931	1930	7	3
	20	1937	1935	1933	1931	1929	1927	1925	1923	1922	1920	1919	1917	8	2
	30	1925	1923	1921	1919	1917	1915	1913	1911	1910	1908	1906	1904	9	1
	40	1912	1910	1908	1906	1904	1902	1900	1898	1897	1895	1894	[illegible]		
	50	1900	1898	1896	1894	1892	1890	1888	1886	1885	1883	1881	1880	Sec.	Cor.
60	0	1887	1885	1883	1881	1879	1877	1875	1873	1872	1870	1869	1867	0	12
	10	1875	1873	1871	1869	1867	1865	1863	1861	1860	1858	1857	1855	1	11
	20	1862	1860	1858	1856	1854	1852	1851	1849	1847	1845	1844	1842	2	10
	30	1850	1848	1846	1844	1842	1840	1838	1836	1835	1833	1832	1830	3	8
	40	1837	1835	1833	1831	1830	1828	1826	1824	1823	1821	1820	1818	4	7
	50	1825	1823	1821	1819	1817	1815	1814	1812	1811	1809	1807	1806	5	6
61	0	1813	1811	1809	1807	1805	1803	1802	1800	1798	1796	1795	1793	6	5
	10	1801	1799	1797	1795	1793	1791	1789	1787	1786	1784	1783	1781	7	3
	20	1789	1787	1785	1783	1781	1779	1777	1775	1774	1772	1771	1769	8	2
	30	1776	1774	1772	1770	1769	1767	1765	1763	1762	1760	1759	1757	9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt. D's cen.		D's Horizontal Parallax.								Table A. Proportional part for Seconds of Parallax. Add.											Tab B. For M. of alt. Add.	
D.	M.	54′	55′	56′	57′	58′	59′	60′	61′	S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	M.	S.
36	0	16.31	15.43	14.54	14. 6	13.17	12.29	11.40	10.51	0	47	46	45	45	44	43	42	41	41	40	0 1 2 3 4 5 6 7 8 9	0 1 1 2 2 3 3 4 4 5
	10	16.36	15.48	15. 0	14.11	13.23	12.34	11.46	10.57	10	39	38	37	37	36	35	34	33	33	32		
	20	16.42	15.53	15. 5	14.17	13.28	12.40	11.51	11. 3	20	31	30	29	28	28	27	26	25	24	24		
	30	16.47	15.58	15.10	14.22	13.34	12.45	11.57	11. 9	30	23	22	21	20	20	19	18	17	16	16		
	40	16.52	16. 4	15.16	14.27	13.39	12.51	12. 3	11.15	40	15	14	13	12	12	11	10	9	8	8		
	50	16.57	16. 9	15.21	14.33	13.45	12.57	12. 9	11.21	50	7	6	5	4	4	3	2	1	0	0		
37	0	17. 2	16.14	15.26	14.38	13.50	13. 3	12.15	11.27	0	47	46	45	45	44	43	42	41	41	40	0 1 2 3 4 5 6 7 8 9	0 1 1 2 2 3 3 4 5 5
	10	17. 7	16.20	15.32	14.44	13.56	13. 8	12.20	11.33	10	39	38	37	37	36	35	34	34	33	32		
	20	17.13	16.25	15.37	14.50	14. 2	13.14	12.26	11.39	20	31	30	30	29	28	27	26	26	25	24		
	30	17.18	16.30	15.43	14.55	14. 8	13.20	12.32	11.45	30	23	22	22	21	20	19	18	18	17	16		
	40	17.23	16.36	15.48	15. 1	14.13	13.26	12.38	11.51	40	15	14	14	13	12	11	10	10	9	8		
	50	17.29	16.41	15.54	15. 6	14.19	13.32	12.44	11.57	50	7	7	6	5	4	3	3	2	1	0		
38	0	17.35	16.48	16. 0	15.13	14.26	13.38	12.51	12. 4	0	46	45	44	44	43	42	41	41	40	39	0 1 2 3 4 5 6 7 8 9	0 1 1 2 2 3 3 4 5 5
	10	17.40	16.53	16. 6	15.19	14.32	13.44	12.57	12.10	10	38	37	37	36	35	34	33	33	32	31		
	20	17.46	16.59	16.12	15.25	14.37	13.50	13. 3	12.16	20	30	30	29	28	27	26	26	25	24	23		
	30	17.51	17. 4	16.17	15.30	14.43	13.56	13. 9	12.22	30	22	22	21	20	19	19	18	17	16	15		
	40	17.57	17.10	16.23	15.36	14.49	14. 2	13.15	12.29	40	15	14	13	12	12	11	10	9	8	8		
	50	18. 2	17.15	16.29	15.42	14.55	14. 8	13.22	12.35	50	7	6	5	4	4	3	2	1	1	0		
39	0	18. 8	17.21	16.34	15.48	15. 1	14.14	13.28	12.41	0	46	45	44	44	43	42	41	41	40	39	0 1 2 3 4 5 6 7 8 9	0 1 1 2 2 3 4 4 5 5
	10	18.13	17.27	16.40	15.54	15. 7	14.20	13.34	12.47	10	38	37	37	36	35	34	34	33	32	31		
	20	18.19	17.32	16.46	15.59	15.13	14.27	13.40	12.54	20	31	30	29	28	27	27	26	25	24	24		
	30	18.24	17.33	16.52	16. 5	15.19	14.33	13.46	13. 0	30	23	22	21	20	20	19	18	17	17	16		
	40	18.30	17.44	16.57	16.11	15.25	14.39	13.53	13. 6	40	15	14	14	13	12	11	10	10	9	8		
	50	18.36	17.49	17. 3	16.17	15.31	14.45	13.59	13.13	50	7	7	6	5	4	3	3	2	1	0		
40	0	18.42	17 56	17.10	16.24	15.38	14.52	14. 6	13.20	0	45	44	43	43	42	41	40	40	39	38	0 1 2 3 4 5 6 7 8 9	0 1 1 2 2 3 4 4 5 6
	10	18.48	18 2	17.16	16.30	15.44	14.59	14.13	13.27	10	37	37	36	35	34	34	33	32	31	31		
	20	18.54	18. 8	17.22	16.36	15.51	15. 5	14.19	13.33	20	30	29	28	27	27	26	25	24	24	23		
	30	18.59	18.14	17.28	16.42	15.57	15.11	14.25	13.40	30	22	21	21	20	19	18	18	17	16	15		
	40	19. 5	18.19	17.34	16.48	16. 3	15.17	14.32	13.46	40	15	14	13	12	11	11	10	9	8	8		
	50	19.11	18.25	17.40	16.55	16. 9	15.24	14.38	13.53	50	7	6	5	5	4	3	2	2	1	0		
41	0	19.18	18.32	17.47	17. 2	16.16	15.31	14.46	14. 0	0	44	43	42	42	41	40	39	39	38	37	0 1 2 3 4 5 6 7 8 9	0 1 1 2 2 3 4 4 5 6
	10	19.23	18.38	17.53	17. 8	16.23	15.37	14.52	14. 7	10	36	36	35	34	33	33	32	31	30	30		
	20	19.29	18.44	17.59	17.14	16.29	15.44	14.59	14.14	20	29	28	27	27	26	25	24	24	23	22		
	30	19.35	18.50	18. 5	17.20	16.35	15.50	15. 5	14.20	30	21	21	20	19	18	18	17	16	15	15		
	40	19.41	18.56	18.11	17.26	16.42	15.57	15.12	14.27	40	14	13	12	12	11	10	9	9	8	7		
	50	19.47	19. 2	18.17	17.33	16.48	16. 3	15.19	14.34	50	6	6	5	4	3	3	2	1	0	0		

EXAMPLE VI.

Given the moon's apparent altitude 11° 20′, and horizontal parallax 60′ 43″. Required the correction and logarithm?

To find the Correction.

In Tab. xix. to alt. 11° 20′ and par. 60 is	4′ 30″
.. Tab. A. 43″ parallax..................	16
.. Tab. B. 0′ altitude....................	2
Sought correction	4′ 48″

To find the Logarithm.

Tab. xix. to nearest alt. 11° 20′ and par. 60′ 40″	2052
Tab. C. 3″ parallax	9
Sought logarithm......................	2061

EXAMPLE VII.

Given the moon's apparent altitude 8° 40′, and horizontal parallax 56 20′ Required the correction and logarithm?

To find the Correction.

In Tab. xix. to alt. 8° 40′ and par. 56′ is	9′ 18″
.. Tab. A. 20″ parallax..................	38
.. Tab. B. 0′ altitude	5
Sought correction	10′ 1″

To find the Logarithm.

Tab. xix. to nearest alt. 8° 39′ and par. 56′ 20′	2518
Tab. C. 0″ parallax............................	13
Sought logarithm	2531

Digitized by Google

TABLE XIX.

Logarithms.

☽'s Hor. Parallax. M.	S.	Apparent Altitude of ☽'s centre. 36°	36½°	37°	37½°	38°	38½°	39°	39½°	40°	40½°	41°	41½°
54	0	2337	2335	2334	2332	2331	2329	2328	2327	2326	2324	2323	2322
	10	2323	2321	2320	2318	2317	2315	2314	2313	2312	2310	2309	2308
	20	2309	2307	2306	2304	2303	2302	2301	2300	2298	2297	2296	2294
	30	2296	2294	2293	2291	2290	2288	2287	2286	2285	2283	2282	2281
	40	2282	2280	2279	2277	2276	2274	2273	2272	2271	2270	2268	2267
	50	2268	2266	2265	2264	2263	2261	2260	2258	2257	2256	2255	2254
55	0	2255	2253	2252	2250	2249	2247	2246	2245	2244	2242	2241	2240
	10	2241	2239	2238	2236	2235	2234	2233	2232	2230	2229	2228	2227
	20	2228	2226	2225	2223	2222	2220	2219	2218	2217	2215	2214	2213
	30	2214	2212	2211	2210	2209	2207	2206	2204	2203	2202	2201	2200
	40	2201	2199	2198	2196	2195	2193	2192	2191	2190	2189	2188	2186
	50	2188	2186	2185	2183	2182	2180	2179	2178	2177	2175	2174	2173
56	0	2174	2173	2171	2169	2168	2167	2166	2164	2163	2162	2161	2160
	10	2161	2159	2158	2156	2155	2153	2152	2151	2150	2149	2148	2147
	20	2148	2146	2145	2143	2142	2140	2139	2138	2137	2135	2134	2133
	30	2135	2133	2132	2130	2129	2127	2126	2125	2124	2122	2121	2120
	40	2121	2119	2118	2117	2116	2114	2113	2112	2111	2109	2108	2107
	50	2108	2106	2105	2104	2103	2101	2100	2099	2097	2096	2095	2094
57	0	2095	2093	2092	2090	2089	2088	2087	2086	2084	2083	2082	2081
	10	2082	2080	2079	2077	2076	2075	2074	2073	2071	2070	2069	2068
	20	2069	2067	2066	2064	2063	2062	2061	2060	2058	2057	2056	2055
	30	2056	2054	2053	2051	2050	2049	2048	2047	2046	2044	2043	2042
	40	2043	2041	2040	2039	2038	2036	2035	2034	2033	2031	2030	2029
	50	2030	2028	2027	2026	2025	2023	2022	2021	2020	2018	2017	2016
58	0	2017	2016	2015	2013	2012	2010	2009	2008	2007	2006	2005	2003
	10	2005	2003	2002	2000	1999	1997	1996	1995	1994	1993	1992	1991
	20	1992	1990	1989	1987	1986	1985	1984	1982	1981	1980	1979	1978
	30	1979	1977	1976	1975	1974	1973	1971	1970	1969	1967	1966	1965
	40	1966	1965	1964	1962	1961	1960	1958	1957	1956	1955	1954	1953
	50	1954	1952	1951	1949	1948	1947	1946	1944	1943	1942	1941	1940
59	0	1941	1939	1938	1937	1936	1934	1933	1932	1931	1929	1928	1927
	10	1929	1927	1926	1924	1923	1921	1920	1919	1918	1917	1916	1915
	20	1916	1914	1913	1911	1910	1909	1908	1907	1906	1904	1903	1902
	30	1903	1902	1901	1899	1898	1896	1895	1894	1893	1892	1891	1890
	40	1891	1889	1888	1886	1885	1884	1883	1882	1881	1879	1878	1877
	50	1879	1877	1876	1874	1873	1871	1870	1869	1868	1867	1866	1865
60	0	1866	1864	1863	1862	1861	1859	1858	1857	1856	1855	1854	1853
	10	1854	1852	1851	1849	1848	1847	1846	1845	1844	1843	1841	1840
	20	1841	1840	1839	1837	1836	1834	1833	1832	1831	1830	1829	1828
	30	1829	1827	1826	1825	1824	1822	1821	1820	1819	1818	1817	1816
	40	1817	1815	1814	1812	1811	1810	1809	1808	1807	1805	1804	1803
	50	1805	1803	1802	1800	1799	1798	1797	1796	1795	1793	1792	1791
61	0	1792	1791	1790	1788	1787	1785	1784	1783	1782	1781	1780	1779
	10	1780	1778	1777	1776	1775	1773	1772	1771	1770	1769	1768	1767
	20	1768	1766	1765	1764	1763	1761	1760	1759	1758	1757	1756	1755
	30	1756	1754	1753	1752	1751	1749	1748	1747	1746	1745	1744	1743

TABLE C. Cor. Sec. of Par. Add.

Sec.	Cor.	Sec.	Cor.	Sec.	Cor.	Sec.	Cor.
0	12	0	12	0	12	0	12
1	11	1	11	1	11	1	11
2	9	2	9	2	9	2	10
3	8	3	8	3	8	3	8
4	7	4	7	4	7	4	7
5	5	5	5	5	6	5	6
6	4	6	4	6	4	6	5
7	2	7	3	7	3	7	3
8	1	8	2	8	2	8	2
9	0	9	0	9	1	9	1

Digitized by Google

TABLE XIX.

Correction

App. Alt. ☽'s cen.		☽'s Horizontal Parallax.								Table A. Proportional part for Seconds of Parallax. Add.											Tab. B For M. of Alt. Add.	
D.	M.	54′	55′	56′	57′	58′	59′	60′	61′	S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	M.	S.
42	0	19.53	19. 8	18.24	17.39	16.54	16.10	15.25	14.41	0	44	43	43	42	41	40	40	39	38	37	0 1 2 3 4 5 6 7 8 9	0 1 1 2 3 3 4 4 5 6
	10	19.59	19.14	18.30	17.45	17. 1	16.16	15.32	14.47	10	37	36	35	34	34	33	32	31	31	30		
	20	20. 5	19.20	18.36	17.52	17. 7	16.23	15.39	14.54	20	29	28	28	27	26	26	25	24	23	23		
	30	20.11	19.26	18.42	17.58	17.14	16.29	15.45	15. 1	30	22	21	20	20	19	18	17	17	16	15		
	40	20.17	19.33	18.48	18. 4	17.20	16.36	15.52	15. 8	40	14	14	13	12	11	11	10	9	9	8		
	50	20.23	19.39	18.55	18.11	17.27	16.43	15.59	15.15	50	7	6	6	5	4	3	3	2	1	0		
43	0	20.30	19.46	19. 2	18.18	17.34	16.50	16. 6	15.23	0	43	42	42	41	40	39	39	38	37	36	0 1 2 3 4 5 6 7 8 9	0 1 1 2 3 3 4 5 5 6
	10	20.36	19.52	19. 8	18.25	17.41	16.57	16.13	15.30	10	36	35	34	34	33	32	31	31	30	29		
	20	20.42	19.58	19.15	18.31	17.47	17. 4	16.20	15.37	20	28	28	27	26	26	25	24	23	23	22		
	30	20.48	20. 5	19.21	18.38	17.54	17.11	16.27	15.44	30	21	21	20	19	18	18	17	16	15	15		
	40	20.54	20.11	19.28	18.44	18. 1	17.17	16.34	15.51	40	14	13	13	12	11	10	10	9	8	7		
	50	21. 0	20.17	19.34	18.51	18. 7	17.24	16.41	15.58	50	7	6	5	5	4	3	2	2	1	0		
44	0	21. 8	20.25	19.41	18.58	18.15	17.32	16.49	16. 6	0	42	41	41	40	39	38	38	37	36	35	0 1 2 3 4 5 6 7 8 9	0 1 1 2 3 3 4 5 5 6
	10	21.14	20.31	19.48	19. 5	18.22	17.39	16.56	16.13	10	35	34	33	33	32	31	31	30	29	28		
	20	21.20	20.37	19.54	19.11	18.28	17.46	17. 3	16.20	20	28	27	26	26	25	24	23	23	22	21		
	30	21.26	20.44	20. 1	19.18	18.35	17.52	17.10	16.27	30	21	20	19	18	18	17	16	16	15	14		
	40	21.33	20.50	20. 7	19.25	18.42	17.59	17.17	16.34	40	13	13	12	11	11	10	9	8	8	7		
	50	21.39	20.56	20.14	19.32	18.49	18. 6	17.24	16.41	50	6	6	5	4	3	3	2	1	1	0		
45	0	21.46	21. 4	20.21	19.39	18.57	18.14	17.32	16.49	0	41	40	40	39	38	37	37	36	35	35	0 1 2 3 4 5 6 7 8 9	0 1 1 2 3 3 4 5 5 6
	10	21.53	21.10	20.28	19.46	19. 3	18.21	17.39	16.57	10	34	33	33	32	31	30	30	29	28	28		
	20	21.59	21.17	20.35	19.52	19.10	18.28	17.46	17. 4	20	27	26	26	25	24	23	23	22	21	21		
	30	22. 5	21.23	20.41	19.59	19.17	18.35	17.53	17.11	30	20	19	19	18	17	16	16	15	14	14		
	40	22.12	21.30	20.48	20. 6	19.24	18.42	18. 0	17.18	40	13	12	12	11	10	9	9	8	7	7		
	50	22.18	21.36	20.55	20.13	19.31	18.49	18. 7	17.26	50	6	5	5	4	3	2	2	1	0	0		
46	0	22.25	21.43	21. 1	20.20	19.38	18.56	18.15	17.33	0	41	40	40	39	38	38	37	36	35	35	0 1 2 3 4 5 6 7 8 9	0 1 1 2 3 4 4 5 6 6
	10	22.31	21.50	21. 8	20.27	19.45	19. 3	18.22	17.40	10	34	33	33	32	31	31	30	29	29	28		
	20	22.38	21.56	21.15	20.33	19.52	19.11	18.29	17.48	20	27	27	26	25	24	24	23	22	22	21		
	30	22.44	22. 3	21.22	20.40	19.59	19.18	18.36	17.55	30	20	20	19	18	18	17	16	15	15	14		
	40	22.51	22.10	21.28	20.47	20. 6	19.25	18.44	18. 2	40	13	13	12	11	11	10	9	9	8	7		
	50	22.57	22.16	21.35	20.54	20.13	19.32	18.51	18.10	50	7	6	5	4	4	3	2	2	1	0		
47	0	23. 5	22.24	21.43	21. 2	20.21	19.40	18.59	18.18	0	40	39	39	38	37	37	36	35	35	34	0 1 2 3 4 5 6 7 8 9	0 1 1 2 3 4 4 5 6 6
	10	23.11	22.31	21.50	21. 9	20.28	19.47	19. 7	18.26	10	33	33	32	31	31	30	29	28	28	27		
	20	23.18	22.37	21.57	21.16	20.35	19.55	19.14	18.33	20	26	26	25	24	24	23	22	22	21	20		
	30	23.25	22.44	22. 4	21.23	20.43	20. 2	19.21	18.41	30	20	19	18	18	17	16	16	15	14	14		
	40	23.31	22.51	22.11	21.30	20.50	20. 9	19.29	18.48	40	13	12	12	11	10	10	9	8	8	7		
	50	23.38	22.58	22.18	21.37	20.57	20.17	19.36	18.56	50	6	5	5	4	3	3	2	1	1	0		
48	0	23.46	23. 6	22.25	21.45	21. 5	20.25	19.45	19. 5	0	39	38	38	37	36	36	35	34	34	33	0 1 2 3 4 5 6 7 8 9	0 1 1 2 3 4 4 5 6 7
	10	23.52	23.12	22.32	21.52	21.12	20.32	19.52	19.12	10	32	32	31	30	30	29	28	28	27	26		
	20	23.59	23.19	22.39	22. 0	21.20	20.40	20. 0	19.20	20	26	25	24	24	23	22	22	21	20	20		
	30	24. 6	23.26	22.46	22. 7	21.27	20.47	20. 7	19.28	30	19	18	18	17	16	16	15	14	14	13		
	40	24.13	23.33	22.53	22.14	21.34	20.55	20.15	19.35	40	12	12	11	10	10	9	8	8	7	6		
	50	24.20	23.40	23. 1	22.21	21.42	21. 2	20.23	19.43	50	6	5	4	4	3	2	2	1	0	0		
49	0	24.27	23.48	23. 9	22.29	21.50	21.10	20.31	19.52	0	38	37	37	36	35	35	34	33	33	32	0 1 2 3 4 5 6 7 8 9	0 1 1 2 3 4 4 5 6 7
	10	24.34	23.55	23.16	22.36	21.57	21.18	20.39	20. 0	10	31	31	30	30	29	28	28	27	26	26		
	20	24.41	24. 2	23.23	22.44	22. 5	21.26	20.46	20. 7	20	25	24	24	23	22	22	21	20	20	19		
	30	24.48	24. 9	23.30	22.51	22.12	21.33	20.54	20.15	30	18	18	17	17	16	15	15	14	13	13		
	40	24.55	24.16	23.37	22.58	22.19	21.41	21. 2	20.23	40	12	11	11	10	9	9	8	7	7	6		
	50	25. 2	24.23	23.44	23. 6	22.27	21.48	21. 9	20.31	50	5	5	4	4	3	2	2	1	0	0		

Digitized by Google

TABLE XIX.

Logarithms.

☽'s Hor. Parallax.		Apparent Altitude of ☽'s centre.												Table C. Cor. Sec. of Par. Add.	
M.	S.	42°	42½°	43°	43½°	44°	44½°	45°	45½°	46°	47°	48°	49°	Sec.	Cor.
54	0	2321	2320	2319	2318	2317	2316	2315	2314	2313	2311	2309	2308	0	12
	10	2307	2306	2305	2304	2303	2302	2301	2300	2299	2297	2296	2294	1	11
	20	2293	2292	2291	2290	2289	2288	2287	2286	2285	2284	2282	2280	2	9
	30	2280	2279	2278	2277	2276	2275	2274	2273	2272	2270	2268	2267	3	8
	40	2266	2265	2264	2263	2262	2261	2260	2259	2258	2256	2255	2253	4	7
	50	2253	2251	2250	2249	2248	2247	2246	2246	2245	2243	2241	2240	5	5
55	0	2239	2238	2237	2236	2235	2234	2233	2232	2231	2229	2228	2226	6	4
	10	2226	2224	2223	2222	2221	2220	2219	2219	2218	2216	2214	2213	7	3
	20	2212	2211	2210	2209	2208	2207	2206	2205	2204	2203	2201	2199	8	1
	30	2199	2198	2197	2196	2195	2194	2193	2192	2191	2189	2188	2186	9	0
	40	2185	2184	2183	2182	2181	2180	2179	2179	2178	2176	2174	2173		
	50	2172	2171	2170	2169	2168	2167	2166	2165	2164	2163	2161	2159	Sec.	Cor.
56	0	2159	2158	2157	2156	2155	2154	2153	2152	2151	2149	2148	2146	0	12
	10	2146	2144	2143	2142	2141	2140	2139	2138	2138	2136	2134	2133	1	11
	20	2132	2131	2130	2129	2128	2127	2126	2125	2125	2123	2121	2120	2	9
	30	2119	2118	2117	2116	2115	2114	2113	2112	2111	2110	2108	2107	3	8
	40	2106	2105	2104	2103	2102	2101	2100	2099	2098	2097	2095	2093	4	7
	50	2093	2092	2091	2090	2089	2088	2087	2086	2085	2084	2082	2080	5	5
57	0	2080	2079	2078	2077	2076	2075	2074	2073	2072	2071	2069	2067	6	4
	10	2067	2066	2065	2064	2063	2062	2061	2060	2059	2058	2056	2054	7	3
	20	2054	2053	2052	2051	2050	2049	2048	2047	2046	2045	2043	2042	8	2
	30	2041	2040	2039	2038	2037	2036	2035	2034	2033	2032	2030	2029	9	0
	40	2028	2027	2026	2025	2024	2023	2022	2021	2021	2019	2017	2016		
	50	2015	2014	2013	2012	2011	2010	2009	2008	2008	2006	2005	2003	Sec.	Cor.
58	0	2002	2001	2000	1999	1998	1998	1997	1996	1995	1993	1992	1990	0	12
	10	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981	1979	1977	1	11
	20	1977	1976	1975	1974	1973	1972	1971	1970	1970	1968	1966	1965	2	9
	30	1964	1963	1962	1961	1960	1959	1958	1957	1957	1955	1954	1952	3	8
	40	1952	1951	1950	1949	1948	1947	1946	1945	1944	1943	1941	1939	4	7
	50	1939	1938	1937	1936	1935	1934	1933	1932	1932	1930	1928	1927	5	6
59	0	1926	1925	1924	1923	1922	1922	1921	1920	1919	1917	1916	1914	6	4
	10	1914	1913	1912	1911	1910	1909	1908	1907	1906	1905	1903	1902	7	3
	20	1901	1900	1899	1898	1897	1897	1896	1895	1894	1892	1891	1889	8	2
	30	1889	1888	1887	1886	1885	1884	1883	1882	1882	1880	1878	1877	9	1
	40	1876	1875	1874	1873	1872	1872	1871	1870	1869	1867	1866	1864		
	50	1864	1863	1862	1861	1860	1859	1858	1857	1857	1855	1854	1852	Sec.	Cor.
60	0	1852	1851	1850	1849	1848	1847	1846	1845	1844	1843	1841	1840	0	12
	10	1839	1838	1837	1836	1835	1835	1834	1833	1832	1830	1829	1827	1	11
	20	1827	1826	1825	1824	1823	1822	1821	1820	1820	1818	1817	1815	2	10
	30	1815	1814	1813	1812	1811	1810	1809	1808	1808	1806	1804	1803	3	8
	40	1802	1801	1800	1800	1799	1798	1797	1796	1795	1794	1792	1791	4	7
	50	1790	1789	1788	1787	1786	1786	1785	1784	1783	1782	1780	1779	5	6
61	0	1778	1777	1776	1775	1774	1774	1773	1772	1771	1769	1768	1766	6	5
	10	1766	1765	1764	1763	1762	1761	1760	1759	1759	1757	1756	1754	7	3
	20	1754	1753	1752	1751	1750	1749	1748	1747	1747	1745	1744	1742	8	2
	30	1742	1741	1740	1739	1738	1737	1736	1735	1735	1733	1732	1730	9	1

Digitized by Google

TABLE XIX

Correction.

App. Alt. D	☽'s cen. M.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Table A. Proportional part for Seconds of Parallax. Add. S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	Tab. B. For M. of Alt. Add. M.	S.
50	0	25. 9	24.30	23.51	23.13	22.34	21.56	21.17	20.39	0	38	37	37	36	35	35	34	34	33	32	0 1 2 3 4 5 6 7 8 9	0 1 1 2 3 4 4 5 6 7
	10	25.16	24.37	23.59	23.20	22.42	22. 3	21.25	20.47	10	32	31	30	30	29	28	28	27	27	26		
	20	25.23	24.44	24. 6	23.28	22.49	22.11	21.33	20.54	20	25	25	24	23	23	22	21	21	20	19		
	30	25.30	24.51	24.13	23.35	22.57	22.19	21.41	21. 2	30	19	18	18	17	16	16	15	14	14	13		
	40	25.37	24.59	24.21	23.42	23. 4	22.26	21.48	21.10	40	12	12	11	11	10	9	9	8	7	7		
	50	25.44	25. 6	24.28	23.50	23.12	22.34	21.56	21.18	50	6	5	5	4	4	3	2	2	1	0		
51	0	25.52	25.14	24.36	23.58	23.21	22.43	22. 5	21.27	0	37	36	36	35	35	34	33	33	32	31	0 1 2 3 4 5 6 7 8 9	0 1 2 2 3 4 5 5 6 7
	10	25.59	25.21	24.43	24. 6	23.28	22.51	22.13	21.35	10	31	30	30	29	28	28	27	26	26	25		
	20	26. 6	25.28	24.51	24.13	23.36	22.58	22.21	21.43	20	25	24	23	23	22	21	21	20	20	19		
	30	26.13	25.36	24.58	24.21	23.43	23. 6	22.29	21.51	30	18	18	17	16	16	15	15	14	13	13		
	40	26.20	25.43	25. 6	24.28	23.51	23.14	22.37	21.59	40	12	11	11	10	10	9	8	8	7	6		
	50	26.27	25.50	25.13	24.36	23.59	23.22	22.45	22. 8	50	6	5	5	4	3	3	2	1	1	0		
52	0	26.35	25.58	25.21	24.44	24. 7	23.31	22.54	22.17	0	36	35	35	34	34	33	32	32	31	31	0 1 2 3 4 5 6 7 8 9	0 1 2 2 3 4 5 5 6 7
	10	26.42	26. 6	25.29	24.52	24.15	23.38	23. 2	22.25	10	30	29	29	28	27	27	26	26	25	24		
	20	26.50	26.13	25.36	25. 0	24.23	23.46	23.10	22.33	20	24	23	23	22	21	21	20	20	19	18		
	30	26.57	26.20	25.44	25. 7	24.31	23.54	23.18	22.41	30	18	17	16	16	15	15	14	13	13	12		
	40	27. 4	26.28	25.51	25.15	24.39	24. 2	23.26	22.49	40	12	11	10	10	9	9	8	7	7	6		
	50	27.11	26.35	25.59	25.23	24.46	24.10	23.34	22.58	50	6	5	4	4	3	2	2	1	1	0		
53	0	27.20	26.43	26. 7	25.31	24.55	24.19	23.43	23. 7	0	35	34	34	33	33	32	31	31	30	30	0 1 2 3 4 5 6 7 8 9	0 1 2 2 3 4 5 5 6 7
	10	27.27	26.51	26.15	25.39	25. 3	24.27	23.51	23.15	10	29	28	28	27	27	26	25	25	24	24		
	20	27.34	26.58	26.22	25.47	25.11	24.35	23.59	23.23	20	23	22	22	21	21	20	20	19	18	18		
	30	27.41	27. 6	26.30	25.54	25.19	24.43	24. 7	23.32	30	17	17	16	15	15	14	14	13	12	12		
	40	27.49	27.13	26.38	26. 2	25.27	24.51	24.15	23.40	40	11	11	10	9	9	8	8	7	6	6		
	50	27.56	27.21	26.45	26.10	25.34	24.59	24.24	23.48	50	5	5	4	3	3	2	2	1	0	0		
54	0	28. 4	27.29	26.54	26.19	25.43	25. 8	24.33	23.58	0	34	33	33	32	32	31	31	30	29	29	0 1 2 3 4 5 6 7 8 9	0 1 2 2 3 4 5 6 6 7
	10	28.12	27.37	27. 2	26.26	25.51	25.16	24.41	24. 6	10	28	28	27	26	26	25	25	24	24	23		
	20	28.19	27.44	27. 9	26.34	25.59	25.24	24.49	24.14	20	22	22	21	21	20	19	19	18	18	17		
	30	28.27	27.52	27.17	26.42	26. 7	25.32	24.58	24.23	30	17	16	15	15	14	14	13	12	12	11		
	40	28.34	27.59	27.25	26.50	26.15	25.41	25. 6	24.31	40	11	10	10	9	8	8	7	7	6	5		
	50	28.42	28. 7	27.32	26.58	26.23	25.49	25.14	24.40	50	5	4	4	3	3	2	1	1	0	0		
55	0	28.50	28.16	27.41	27. 7	26.32	25.58	25.24	24.49	0	33	32	32	31	31	30	30	29	28	28	0 1 2 3 4 5 6 7 8 9	0 1 2 2 3 4 5 6 6 7
	10	28.58	28.23	27.49	27.15	26.40	26. 6	25.32	24.58	10	27	27	26	26	25	24	24	23	23	22		
	20	29. 5	28.31	27.57	27.23	26.49	26.14	25.40	25. 6	20	22	21	21	20	19	19	18	18	17	17		
	30	29.13	28.39	28. 5	27.31	26.57	26.23	25.49	25.15	30	16	15	15	14	14	13	13	12	11	11		
	40	29.20	28.46	28.12	27.39	27. 5	26.31	25.57	25.23	40	10	10	9	9	8	7	7	6	6	5		
	50	29.28	28.54	28.20	27.47	27.13	26.39	26. 5	25.32	50	5	4	3	3	2	2	1	1	0	0		
56	0	29.35	29. 2	28.28	27.55	27.21	26.47	26.14	25.40	0	33	32	32	31	31	30	30	29	29	28	0 1 2 3 4 5 6 7 8 9	0 1 2 2 3 4 5 6 7 7
	10	29.43	29. 9	28.36	28. 3	27.29	26.56	26.22	25.49	10	27	27	26	26	25	25	24	24	23	22		
	20	29.50	29.17	28.44	28.11	27.37	27. 4	26.31	25.58	20	22	21	21	20	20	19	19	18	18	17		
	30	29.58	29.25	28.52	28.19	27.46	27.12	26.39	26. 6	30	16	16	15	15	14	14	13	13	12	11		
	40	30. 6	29.33	29. 0	28.27	27.54	27.21	26.48	26.15	40	11	10	10	9	9	8	8	7	6	6		
	50	30.13	29.40	29. 8	28.35	28. 2	27.29	26.56	26.23	50	5	5	4	4	3	3	2	1	1	0		
57	0	30.22	29.49	29.17	28.44	28.11	27.39	27. 6	26.33	0	32	31	31	30	30	29	29	28	28	27	0 1 2 3 4 5 6 7 8 9	0 1 2 2 3 4 5 6 7 7
	10	30.30	29.57	29.25	28.52	28.19	27.47	27.14	26.42	10	27	26	26	25	24	24	23	23	22	22		
	20	30.37	30. 5	29.33	29. 0	28.28	27.55	27.23	26.51	20	21	21	20	20	19	19	18	17	17	16		
	30	30.45	30.13	29.41	29. 8	28.36	28. 4	27.32	26.59	30	16	15	15	14	14	13	13	12	12	11		
	40	30.53	30.21	29.49	29.16	28.44	28.12	27.40	27. 8	40	10	10	9	9	8	8	7	7	6	6		
	50	31. 1	30.29	29.57	29.25	28.53	28.21	27.49	27.17	50	5	5	4	3	3	2	2	1	1	0		
58	0	31. 9	30.37	30. 6	29.34	29. 2	28.30	27.58	27.27	0	31	30	30	29	29	28	28	27	27	26	0 1 2 3 4 5 6 7 8 9	0 1 2 2 3 4 5 6 7 7
	10	31.17	30.45	30.14	29.42	29.10	28.39	28. 7	27.35	10	26	25	25	24	24	23	23	22	22	21		
	20	31.25	30.53	30.22	29.50	29.19	28.47	28.16	27.44	20	21	20	19	19	18	18	17	17	16	16		
	30	31.33	31. 1	30.30	29.59	29.27	28.56	28.24	27.53	30	15	15	14	14	13	13	12	12	11	11		
	40	31.40	31. 9	30.38	30. 7	29.36	29. 4	28.33	28. 2	40	10	10	9	8	8	7	7	6	6	5		
	50	31.48	31.17	30.46	30.15	29.44	29.13	28.42	28.11	50	5	4	4	3	3	2	2	1	1	0		
59	0	31.57	31.26	30.55	30.24	29.53	29.23	28.52	28.21	0	30	29	29	28	28	27	27	26	26	25	0 1 2 3 4 5 6 7 8 9	0 1 2 3 3 4 5 6 7 8
	10	32. 5	31.34	31. 3	30.33	30. 2	29.31	29. 0	28.30	10	25	24	24	23	23	22	22	21	21	20		
	20	32.13	31.42	31.12	30.41	30.10	29.40	29. 9	28.39	20	20	19	19	18	18	17	17	16	16	15		
	30	32.21	31.50	31.20	30.49	30.19	29.48	29.18	28.48	30	15	14	14	13	13	12	12	11	11	10		
	40	32.29	31.58	31.28	30.58	30.27	29.57	29.27	28.56	40	10	9	9	8	8	7	7	6	6	5		
	50	32.37	32. 6	31.36	31. 6	30.36	30. 6	29.36	29. 5	50	5	4	4	3	3	2	1	1	0	0		

Digitized by Google

TABLE XIX.

Logarithms.

☽'s Hor. Parallax. M.	S.	Apparent Altitude of ☽'s centre. 50°	51°	52°	53°	54°	55°	56°	57°	58°	59°
54	0	2306	2305	2303	2302	2301	2300	2298	2297	2296	2295
	10	2293	2291	2290	2288	2287	2286	2285	2284	2283	2282
	20	2279	2277	2276	2275	2274	2272	2271	2270	2269	2268
	30	2265	2264	2262	2261	2260	2259	2258	2257	2256	2254
	40	2252	2250	2249	2248	2246	2245	2244	2243	2242	2241
	50	2238	2237	2235	2234	2233	2232	2230	2230	2229	2227
55	0	2225	2223	2222	2221	2219	2218	2217	2216	2215	2214
	10	2211	2210	2208	2207	2206	2205	2204	2203	2202	2201
	20	2198	2196	2195	2194	2193	2191	2190	2189	2188	2187
	30	2184	2183	2182	2180	2179	2178	2177	2176	2175	2174
	40	2171	2170	2168	2167	2166	2165	2164	2163	2162	2161
	50	2158	2156	2155	2154	2153	2152	2150	2149	2148	2147
56	0	2145	2143	2142	2141	2139	2138	2137	2136	2135	2134
	10	2131	2130	2129	2127	2126	2125	2124	2123	2122	2121
	20	2118	2117	2116	2114	2113	2112	2111	2110	2109	2108
	30	2105	2104	2102	2101	2100	2099	2098	2097	2096	2095
	40	2092	2091	2089	2088	2087	2086	2085	2084	2083	2082
	50	2079	2078	2076	2075	2074	2073	2072	2071	2070	2069
57	0	2066	2065	2063	2062	2061	2060	2059	2058	2057	2056
	10	2053	2052	2050	2049	2048	2047	2046	2045	2044	2043
	20	2040	2039	2037	2036	2035	2034	2033	2032	2031	2030
	30	2027	2026	2025	2023	2022	2021	2020	2019	2018	2017
	40	2014	2013	2012	2010	2009	2008	2007	2006	2005	2004
	50	2002	2000	1999	1998	1997	1996	1994	1993	1992	1991
58	0	1989	1987	1986	1985	1984	1983	1982	1981	1980	1979
	10	1976	1975	1973	1972	1971	1970	1969	1968	1967	1966
	20	1963	1962	1961	1960	1958	1957	1956	1955	1954	1953
	30	1951	1949	1948	1947	1946	1945	1944	1943	1942	1941
	40	1938	1937	1936	1934	1933	1932	1931	1930	1929	1928
	50	1926	1924	1923	1922	1921	1920	1918	1917	1917	1916
59	0	1913	1912	1910	1909	1908	1907	1906	1905	1904	1903
	10	1901	1899	1898	1897	1896	1895	1893	1892	1892	1891
	20	1888	1887	1885	1884	1883	1882	1881	1880	1879	1878
	30	1876	1874	1873	1872	1871	1870	1869	1868	1867	1866
	40	1863	1862	1861	1859	1858	1857	1856	1855	1854	1853
	50	1851	1849	1848	1847	1846	1845	1844	1843	1842	1841
60	0	1838	1837	1836	1835	1834	1833	1832	1831	1830	1829
	10	1826	1825	1824	1822	1821	1820	1819	1818	1817	1816
	20	1814	1813	1811	1810	1809	1808	1807	1806	1805	1804
	30	1802	1800	1799	1798	1797	1796	1795	1794	1793	1792
	40	1789	1788	1787	1786	1785	1784	1783	1782	1781	1780
	50	1777	1776	1775	1774	1773	1771	1770	1770	1769	1768
61	0	1765	1764	1763	1761	1760	1759	1758	1757	1757	1756
	10	1753	1752	1751	1749	1748	1747	1746	1745	1744	1743
	20	1741	1740	1739	1737	1736	1735	1734	1733	1732	1731
	30	1729	1728	1727	1725	1724	1723	1722	1721	1720	1719

TABLE C.
Cor. for Seconds of Parallax. Add.

Sec.	Cor.
0	12
1	11
2	9
3	8
4	7
5	5
6	4
7	3
8	1
9	0
Sec.	**Cor.**
0	12
1	11
2	9
3	8
4	7
5	5
6	4
7	3
8	2
9	0
Sec.	**Cor.**
0	12
1	11
2	9
3	8
4	7
5	6
6	4
7	3
8	2
9	1
Sec.	**Cor.**
0	12
1	11
2	10
3	8
4	7
5	6
6	5
7	3
8	2
9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt. ☽'s cen.		☽'s Horizontal Parallax.								Table A. Proportional part for Seconds of Parallax. Add											Tab. B. For M. of Alt. Add.	
D.	M.	54′	55′	56′	57′	58′	59′	60′	61′	S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	M.	S.
60	0	32.45	32.15	31.45	31.15	30.45	30.15	29.45	29.15	0	29	29	28	28	27	27	26	26	25	25	0 1 2 3 4 5 6 7 8 9	0 1 2 3 3 4 5 6 7 8
	10	32.53	32.24	31.54	31.24	30.54	30.24	29.54	29.24	10	24	24	23	23	22	22	21	21	20	20		
	20	33. 1	32.32	32. 2	31.32	31. 3	30.33	30. 3	29.34	20	19	19	18	18	17	17	16	16	15	15		
	30	33. 9	32.40	32.10	31.41	31.11	30.42	30.12	29.43	30	14	14	13	13	12	12	11	11	10	10		
	40	33.17	32.48	32.19	31.49	31.20	30.50	30.21	29.52	40	9	9	8	8	7	7	6	6	5	5		
	50	33.25	32.56	32.27	31.58	31.28	30.59	30.30	30. 1	50	4	4	3	3	2	2	1	1	0	0		
61	0	33.34	33. 5	32.36	32. 7	31.38	31. 9	30.40	30.11	0	28	28	27	27	26	26	25	25	24	24	0 1 2 3 4 5 6 7 8 9	0 1 2 3 3 4 5 6 7 8
	10	33.42	33.14	32.45	32.16	31.47	31.18	30.49	30.20	10	23	23	22	22	21	21	20	20	19	19		
	20	33.51	33.22	32.53	32.24	31.55	31.27	30.58	30.29	20	18	18	17	17	17	16	16	15	15	14		
	30	33.59	33.30	33. 1	32.33	32. 4	31.35	31. 7	30.38	30	14	13	13	12	12	11	11	10	10	9		
	40	34. 7	33.38	33.10	32.41	32.13	31.44	31.16	30.47	40	9	8	8	7	7	6	6	5	5	5		
	50	34.15	33.46	33.18	32.50	32.21	31.53	31.25	30.56	50	4	4	3	3	2	2	1	1	0	0		
62	0	34.24	33.56	33.27	32.59	32.31	32. 3	31.35	31. 7	0	27	27	26	26	25	25	24	24	23	23	0 1 2 3 4 5 6 7 8 9	0 1 2 3 3 4 5 6 7 8
	10	34.32	34. 4	33.36	33. 8	32.40	32.12	31.44	31.16	10	22	22	21	21	21	20	20	19	19	18		
	20	34.40	34.12	33.44	33.17	32.49	32.21	31.53	31.25	20	18	17	17	16	16	15	15	15	14	14		
	30	34.48	34.21	33.53	33.25	32.57	32.30	32. 2	31.34	30	13	13	12	12	11	11	10	10	9	9		
	40	34.56	34.29	34. 1	33.34	33. 6	32.39	32.11	31.44	40	8	8	8	7	7	6	6	5	5	4		
	50	35. 5	34.37	34.10	33.42	33.15	32.48	32.20	31.53	50	4	3	3	2	2	2	1	1	0	0		
63	0	35.14	34.46	34.19	33.52	33.25	32.58	32.30	32. 3	0	26	26	25	25	24	24	23	23	22	22	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 4 5 6 7 8
	10	35.22	34.55	34.28	34. 1	33.34	33. 7	32.39	32.12	10	22	21	21	20	20	19	19	18	18	17		
	20	35.30	35. 3	34.36	34. 9	33.42	33.16	32.49	32.22	20	17	17	16	16	15	15	14	14	13	13		
	30	35.38	35.12	34.45	34.18	33.51	33.25	32.58	32.31	30	13	12	12	11	11	10	10	9	9	9		
	40	35.47	35.20	34.53	34.27	34. 0	33.34	33. 7	32.40	40	8	8	7	7	6	6	5	5	5	4		
	50	35.55	35.28	35. 2	34.36	34. 9	33.43	33.16	32.50	50	4	3	3	2	2	1	1	0	0	0		
64	0	36. 4	35.38	35.12	34.45	34.19	33.53	33.26	33. 0	0	25	25	24	24	23	23	22	22	22	21	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 4 5 6 7 8
	10	36.12	35.46	35.20	34.54	34.28	34. 2	33.36	33. 9	10	21	20	20	19	19	19	18	18	17	17		
	20	36.21	35.55	35.29	35. 3	34.37	34.11	33.45	33.19	20	16	16	16	15	15	14	14	13	13	12		
	30	36.29	36. 3	35.37	35.12	34.46	34.20	33.54	33.28	30	12	12	11	11	10	10	9	9	9	8		
	40	36.37	36.12	35.46	35.20	34.55	34.29	34. 3	33.38	40	8	7	7	6	6	6	5	5	4	4		
	50	36.46	36.20	35.55	35.29	35. 4	34.38	34.13	33.47	50	3	3	3	2	2	1	1	0	0	0		
65	0	36.55	36.30	36. 4	35.39	35.14	34.48	34.23	33.57	0	24	24	23	23	22	22	22	21	21	20	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 4 5 6 7 8
	10	37. 3	36.38	36.13	35.48	35.23	34.57	34.32	34. 7	10	20	19	19	19	18	18	17	17	17	16		
	20	37.12	36.47	36.22	35.57	35.32	35. 6	34.41	34.16	20	16	15	15	14	14	14	13	13	12	12		
	30	37.20	36.55	36.30	36. 5	35.41	35.16	34.51	34.26	30	12	11	11	10	10	9	9	9	8	8		
	40	37.28	37. 4	36.39	36.14	35.50	35.25	35. 0	34.35	40	7	7	7	6	6	5	5	4	4	4		
	50	37.37	37.12	36.48	36.23	35.59	35.34	35. 9	34.45	50	3	3	2	2	2	1	1	0	0	0		
66	0	37.45	37.21	36.56	36.32	36. 8	35.43	35.19	34.54	0	24	24	23	23	22	22	22	21	21	20	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 4 5 6 7 8
	10	37.54	37.29	37. 5	36.41	36.17	35.52	35.28	35. 4	10	20	20	19	19	18	18	18	17	17	16		
	20	38. 2	37.38	37.14	36.50	36.26	36. 2	35.38	35.13	20	16	16	15	15	14	14	14	13	13	12		
	30	38.11	37.47	37.23	36.59	36.35	36.11	35.47	35.23	30	12	12	11	11	10	10	10	9	9	8		
	40	38.19	37.55	37.31	37. 8	36.44	36.20	35.56	35.33	40	8	8	7	7	6	6	6	5	5	4		
	50	38.27	38. 4	37.40	37.17	36.53	36.29	36. 6	35.42	50	4	4	3	3	2	2	2	1	1	0		
67	0	38.37	38.13	37.50	37.27	37. 3	36.40	36.16	35.53	0	23	23	22	22	21	21	21	20	20	20	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 5 6 7 8
	10	38.45	38.22	37.59	37.36	37.12	36.49	36.26	36. 2	10	19	19	18	18	18	17	17	16	16	16		
	20	38.54	38.31	38. 8	37.45	37.21	36.58	36.35	36.12	20	15	15	15	14	14	13	13	13	12	12		
	30	39. 2	38.39	38.17	37.54	37.31	37. 8	36.45	36.22	30	11	11	11	10	10	10	9	9	8	8		
	40	39.11	38.48	38.25	38. 3	37.40	37.17	36.54	36.31	40	8	7	7	6	6	6	5	5	5	[illegible]		
	50	39.19	38.57	38.34	38.12	37.49	37.26	37. 4	36.41	50	4	3	3	3	2	2	2	1	1	[illegible]		
68	0	39.29	39. 7	38.44	38.22	37.59	37.37	37.14	36.52	0	22	22	21	21	21	20	20	19	19	19	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 5 6 7 8
	10	39.38	39.15	38.53	38.31	38. 8	37.46	37.24	37. 1	10	18	18	18	17	17	16	16	16	15	15		
	20	39.46	39.24	39. 2	38.40	38.18	37.55	37.33	37.11	20	15	14	14	14	13	13	12	12	12	11		
	30	39.55	39.33	39.11	38.49	38.27	38. 5	37.43	37.21	30	11	11	10	10	9	9	9	8	8	8		
	40	40. 3	39.41	39.20	38.58	38.36	38.14	37.52	37.30	40	7	7	7	6	6	5	5	5	4	4		
	50	40.12	39.50	39.29	39. 7	38.45	38.24	38. 2	37.40	50	4	3	3	2	2	2	1	1	1	0		
69	0	40.21	40. 0	39.38	39.17	38.55	38.34	38.12	37.51	0	21	21	20	20	20	19	19	19	18	18	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 6 7 8
	10	40.30	40. 9	39.47	39.26	39. 5	38.43	38.22	38. 1	10	17	17	17	16	16	16	15	15	15	14		
	20	40.39	40.18	39.56	39.35	39.14	38.53	38.32	38.10	20	14	14	13	13	13	12	12	12	12	11		
	30	40.47	40.26	40. 5	39.44	39.23	39. 2	38.41	38.20	30	10	10	10	9	9	9	8	8	8	7		
	40	40.56	40.35	40.14	39.53	39.33	39.12	38.51	38.30	40	7	7	6	6	6	5	5	4	4	4		
	50	41. 5	40.44	40.23	40. 3	39.42	39.21	39. 1	38.40	50	3	3	3	2	2	2	1	1	1	0		

Digitized by Google

TABLE XIX.

Logarithms.

☽'s Hor. Parallax.		Apparent Altitude of ☽'s centre.									
M.	S.	60°	61°	62°	63°	64°	65°	66°	67°	68°	69°
54	0	2295	2294	2293	2292	2291	2291	2290	2289	2289	2288
	10	2281	2280	2279	2278	2278	2277	2276	2276	2275	2274
	20	2267	2266	2266	2265	2264	2263	2263	2262	2261	2261
	30	2254	2253	2252	2251	2250	2250	2249	2248	2248	2247
	40	2240	2239	2238	2238	2237	2236	2236	2235	2234	2234
	50	2227	2226	2225	2224	2223	2223	2222	2221	2221	2220
55	0	2213	2212	2212	2211	2210	2209	2209	2208	2207	2207
	10	2200	2199	2198	2197	2197	2196	2195	2195	2194	2194
	20	2186	2186	2185	2184	2183	2183	2182	2181	2181	2180
	30	2173	2172	2171	2171	2170	2169	2169	2168	2167	2167
	40	2160	2159	2158	2157	2157	2156	2155	2155	2154	2154
	50	2147	2146	2145	2144	2143	2143	2142	2141	2141	2140
56	0	2133	2133	2132	2131	2130	2130	2129	2128	2128	2127
	10	2120	2119	2119	2118	2117	2116	2116	2115	2114	2114
	20	2107	2106	2105	2105	2104	2103	2103	2102	2101	2101
	30	2094	2093	2092	2092	2091	2090	2090	2089	2088	2088
	40	2081	2080	2079	2078	2078	2077	2077	2076	2075	2075
	50	2068	2067	2066	2065	2065	2064	2064	2063	2062	2062
57	0	2055	2054	2053	2053	2052	2051	2051	2050	2049	2049
	10	2042	2041	2040	2040	2039	2038	2038	2037	2036	2036
	20	2029	2028	2028	2027	2026	2025	2025	2024	2024	2023
	30	2016	2016	2015	2014	2013	2013	2012	2011	2011	2010
	40	2004	2003	2002	2001	2000	2000	1999	1999	1998	1998
	50	1991	1990	1989	1988	1988	1987	1986	1986	1985	1985
58	0	1978	1977	1976	1976	1975	1974	1974	1973	1972	1972
	10	1965	1965	1964	1963	1962	1962	1961	1960	1960	1959
	20	1953	1952	1951	1950	1950	1949	1948	1948	1947	1947
	30	1940	1939	1938	1938	1937	1936	1936	1935	1934	1934
	40	1927	1927	1926	1925	1924	1924	1923	1923	1922	1921
	50	1915	1914	1913	1912	1912	1911	1911	1910	1909	1909
59	0	1902	1902	1901	1900	1899	1899	1898	1898	1897	1896
	10	1890	1889	1888	1887	1887	1886	1886	1885	1884	1884
	20	1877	1877	1876	1875	1874	1874	1873	1873	1872	1872
	30	1865	1864	1863	1863	1862	1861	1861	1860	1860	1859
	40	1853	1852	1851	1850	1850	1849	1848	1848	1847	1847
	50	1840	1840	1839	1838	1837	1837	1836	1836	1835	1834
60	0	1828	1827	1826	1826	1825	1824	1824	1823	1823	1822
	10	1816	1815	1814	1813	1813	1812	1812	1811	1810	1810
	20	1803	1803	1802	1801	1801	1800	1799	1799	1798	1798
	30	1791	1791	1790	1789	1788	1788	1787	1787	1786	1786
	40	1779	1778	1778	1777	1776	1776	1775	1774	1774	1773
	50	1767	1766	1765	1765	1764	1763	1763	1762	1762	1761
61	0	1755	1754	1753	1753	1752	1751	1751	1750	1750	1749
	10	1743	1742	1741	1740	1740	1739	1739	1738	1737	1737
	20	1731	1730	1729	1728	1728	1727	1727	1726	1725	1725
	30	1719	1718	1717	1716	1716	1715	1715	1714	1713	1713

TABLE C.
Cor. for Seconds of Parallax.
Add.

Sec.	Cor.
0	12
1	11
2	9
3	8
4	7
5	5
6	4
7	3
8	1
9	0
Sec.	**Cor.**
0	12
1	11
2	9
3	8
4	7
5	5
6	4
7	3
8	2
9	0
Sec.	**Cor.**
0	12
1	11
2	9
3	8
4	7
5	6
6	4
7	3
8	2
9	1
Sec.	**Cor.**
0	12
1	11
2	10
3	8
4	7
5	6
6	5
7	4
8	2
9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt. D.	☽'s cor. M.	☽'s Horizontal Parallax. 54	55	56′	57	58′	59′	60′	61′	Table A. Correction for Seconds of Parallax. Add. S	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″
70	0	41.14	40.54	40.33	40.13	39.52	39.32	39.11	38.51	0	20	20	19	19	19	18	18	18	17	17
	10	41.23	41. 3	40.42	40.22	40. 2	39.41	39.21	39. 1	10	17	16	16	16	15	15	15	14	14	14
	20	41.32	41.12	40.51	40.31	40.11	39.51	39.31	39.10	20	13	13	13	12	12	12	11	11	11	10
	30	41.40	41.20	41. 0	40.40	40.20	40. 0	39.40	39.20	30	10	10	9	9	9	8	8	8	7	7
	40	41.49	41.29	41. 9	40.50	40.30	40.10	39.50	39.30	40	7	6	6	6	5	5	5	4	4	4
	50	41.58	41.38	41.18	40.59	40.39	40.19	40. 0	39.40	50	3	3	3	2	2	2	1	1	1	0
71	0	42. 8	41.48	41.28	41. 9	40.49	40.30	40.10	39.51	0	19	19	18	18	18	17	17	17	16	16
	10	42.16	41.57	41.38	41.18	40.59	40.39	40.20	40. 1	10	16	15	15	15	15	14	14	14	13	13
	20	42.25	42. 6	41.47	41.27	41. 8	40.49	40.30	40.11	20	13	12	12	12	11	11	11	10	10	10
	30	42.34	42.15	41.56	41.37	41.18	40.59	40 39	40.20	30	9	9	9	8	8	8	8	7	7	7
	40	42.43	42.24	42. 5	41.46	41.27	41. 8	40.49	40.30	40	6	6	6	5	5	5	4	4	4	3
	50	42.51	42.33	42.14	41.55	41.36	41.18	40.59	40.40	50	3	3	2	2	2	1	1	1	1	0
72	0	43. 1	42.43	42.24	42. 5	41.47	41.28	41.10	40.51	0	18	18	17	17	17	16	16	16	16	15
	10	43.10	42.51	42.33	42.15	41.56	41.38	41.20	41. 1	10	15	15	14	14	14	13	13	13	13	12
	20	43.19	43. 0	42.42	42.24	42. 6	41.48	41.29	41.11	20	12	12	11	11	11	10	10	10	10	9
	30	43.27	43. 9	42.51	42.33	42.15	41.57	41.39	41.21	30	9	9	8	8	8	7	7	7	7	6
	40	43.36	43.18	43. 0	42.43	42.25	42. 7	41.49	41.31	40	6	6	5	5	5	4	4	4	3	3
	50	43.45	43.27	43.10	42.52	42.34	42.17	41.59	41.41	50	3	3	2	2	2	1	1	1	0	0
73	0	43.55	43.37	43.20	43. 2	42.45	42.27	42.10	41.52	0	17	17	16	16	16	16	15	15	15	14
	10	44. 4	43.46	43.29	43.12	42.54	42.37	42.19	42. 2	10	14	14	14	13	13	13	12	12	12	12
	20	44.13	43.55	43.38	43.21	43. 4	42.47	42.29	42.12	20	11	11	11	10	10	10	10	9	9	9
	30	44.21	44. 4	43.47	43.30	43.13	42.56	42.39	42.22	30	8	8	8	8	7	7	7	6	6	6
	40	44.30	44.13	43.57	43.40	43.23	43. 6	42.49	42.32	40	6	5	5	5	4	4	4	4	3	3
	50	44.39	44.22	44. 6	43.49	43.32	43.16	42.59	42.42	50	3	2	2	2	2	1	1	1	0	0
74	0	44.49	44.32	44.16	43.59	43.43	43.26	43.10	42.53	0	16	16	15	15	15	15	14	14	14	14
	10	44.58	44.42	44.25	44. 9	43.52	43.36	43.20	43. 3	10	13	13	13	12	12	12	12	11	11	11
	20	45. 7	44.51	44.34	44.18	44. 2	43.46	43.30	43.13	20	11	10	10	10	10	9	9	9	8	8
	30	45.16	45. 0	44.44	44.28	44.12	43.56	43.40	43.23	30	8	8	7	7	7	7	6	6	6	5
	40	45.25	45. 9	44.53	44.37	44.21	44. 5	43.49	43.34	40	5	5	5	4	4	4	4	3	3	3
	50	45.34	45.18	45. 2	44.46	44.31	44.15	43.59	43.44	50	3	2	2	2	1	1	1	1	0	0
75	0	45.43	45.28	45.12	44.57	44.41	44.26	44.10	43.55	0	15	15	14	14	14	14	13	13	13	13
	10	45.52	45.37	45.22	45. 6	44.51	44.36	44.20	44. 5	10	12	12	12	12	11	11	11	11	10	10
	20	46. 1	45.46	45.31	45.16	45. 1	44.45	44.30	44.15	20	10	10	9	9	9	9	8	8	8	8
	30	46.10	45.55	45.40	45.25	45.10	44.55	44.40	44.25	30	7	7	7	7	6	6	6	6	5	5
	40	46.19	46. 4	45.50	45.35	45.20	45. 5	44.50	44.35	40	5	5	4	4	4	4	3	3	3	3
	50	46.28	46.14	45.59	45.44	45.29	45.15	45. 0	44.45	50	2	2	2	2	1	1	1	1	0	0
76	0	46.38	46.24	46. 9	45.55	45.40	45.26	45.11	44.57	0	14	14	14	13	13	13	13	12	12	12
	10	46.47	46.33	46.18	46. 4	45.50	45.35	45.21	45. 7	10	12	11	11	11	11	10	10	10	10	10
	20	46.56	46.42	46.28	46.14	45.59	45.45	45.31	45.17	20	9	9	9	9	8	8	8	8	7	7
	30	47. 5	46.51	46.37	46.23	46. 9	45.55	45.41	45.27	30	7	7	7	6	6	6	6	5	5	5
	40	47.14	47. 0	46.46	46.33	46.19	46. 5	45.51	45.37	40	5	4	4	4	4	3	3	3	3	3
	50	47.23	47. 9	46.56	46.42	46.28	46.15	46. 1	45.47	50	2	2	2	2	1	1	1	1	0	0
77	0	47.33	47.20	47. 6	46.53	46.39	46.26	46.12	45.59	0	13	13	13	12	12	12	12	11	11	11
	10	47.42	47.29	47.15	47. 2	46.49	46.35	46.22	46. 9	10	11	11	10	10	10	10	10	9	9	9
	20	47.51	47.38	47.25	47.12	46.59	46.45	46.32	46.19	20	9	8	8	8	8	8	7	7	7	7
	30	48. 0	47.47	47.34	47.21	47. 8	46.55	46.42	46.29	30	6	6	6	6	6	5	5	5	5	5
	40	48. 9	47.56	47.44	47.31	47.18	47. 5	46.52	46.39	40	4	4	4	4	3	3	3	3	3	2
	50	48.18	48. 6	47.53	47.40	47.28	47.15	47. 2	46.50	50	2	2	2	1	1	1	1	1	0	0
78	0	48.28	48.16	48. 3	47.51	47.38	47.26	47.13	47. 1	0	12	12	12	11	11	11	11	11	10	10
	10	48 37	48.25	48.13	48. 0	47.48	47.36	47.24	47.11	10	10	10	10	9	9	9	9	9	8	8
	20	48 46	48.34	48.22	48.10	47.58	47.46	47.34	47.21	20	8	8	8	7	7	7	7	7	6	6
	30	48.55	48.44	48.32	48.20	48. 8	47.56	47.44	47.32	30	6	6	6	5	5	5	5	5	4	4
	40	49. 5	48.53	48.41	48.29	48.17	48. 6	47.54	47.42	40	4	4	4	3	3	3	3	3	2	2
	50	49.14	49. 2	48.50	48.39	48.27	48.16	48. 4	47.52	50	2	2	2	1	1	1	1	1	0	0
79	0	49.24	49.12	49. 1	48.49	48.38	48.26	48.15	48. 4	0	11	11	11	10	10	10	10	10	10	9
	10	49.33	49.22	49.10	48.59	48.48	48.36	48.25	48.14	10	9	9	9	9	8	8	8	8	8	8
	20	49.42	49.31	49.20	49. 9	48.57	48.46	48.35	48.24	20	7	7	7	7	7	6	6	6	6	6
	30	49.51	49.40	49.29	49.18	49. 7	48.56	48.45	48.34	30	5	5	5	5	5	5	4	4	4	4
	40	50. 0	49.49	49.39	49.28	49.17	49. 6	48.55	48.45	40	4	3	3	3	3	3	3	2	2	2
	50	50. 9	49.59	49.48	49.37	49.27	49.16	49. 6	48.55	50	2	2	1	1	1	1	1	1	0	0

Tab. B. For M. of Alt. Add.

D.	M.	S.
70	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 6 7 8
71	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 7 8
72	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 8
73	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 7 8
74	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
75	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
76	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
77	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
78	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
79	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9

Digitized by Google

TABLE XIX.

Logarithms.

☽'s Hor. Parallax.		Apparent Altitude of ☽'s Centre.									
M.	S.	70°	71°	72°	73°	74°	75°	76°	77°	78°	79°
54	0	2287	2287	2286	2286	2285	2285	2285	2284	2284	2284
	10	2274	2273	2273	2272	2272	2272	2271	2271	2271	2271
	20	2260	2260	2259	2259	2258	2258	2258	2257	2257	2257
	30	2247	2246	2246	2245	2245	2245	2244	2243	2243	2243
	40	2233	2233	2232	2232	2231	2231	2231	2230	2230	2230
	50	2220	2219	2219	2218	2218	2218	2217	2217	2216	2216
55	0	2206	2206	2205	2205	2204	2204	2204	2203	2203	2203
	10	2193	2192	2192	2191	2191	2191	2190	2190	2190	2190
	20	2179	2179	2179	2178	2178	2178	2177	2176	2176	2176
	30	2166	2166	2165	2165	2164	2164	2164	2163	2163	2163
	40	2153	2152	2152	2152	2151	2151	2150	2150	2150	2150
	50	2140	2139	2139	2138	2138	2138	2137	2137	2137	2137
56	0	2126	2126	2126	2125	2125	2125	2124	2123	2123	2123
	10	2113	2113	2112	2112	2112	2111	2111	2110	2110	2110
	20	2100	2100	2099	2099	2098	2098	2098	2097	2097	2097
	30	2087	2087	2086	2086	2085	2085	2085	2084	2084	2084
	40	2074	2074	2073	2073	2072	2072	2072	2071	2071	2071
	50	2061	2061	2060	2060	2059	2059	2059	2058	2058	2058
57	0	2048	2048	2047	2047	2046	2046	2046	2045	2045	2045
	10	2035	2035	2034	2034	2034	2033	2033	2032	2032	2032
	20	2022	2022	2022	2021	2021	2021	2020	2019	2019	2019
	30	2010	2009	2009	2008	2008	2008	2007	2007	2007	2007
	40	1997	1996	1996	1995	1995	1995	1994	1994	1994	1994
	50	1984	1984	1983	1983	1982	1982	1982	1981	1981	1981
58	0	1971	1971	1970	1970	1970	1970	1969	1968	1968	1968
	10	1959	1958	1958	1957	1957	1957	1956	1956	1956	1956
	20	1946	1946	1945	1945	1944	1944	1944	1943	1943	1943
	30	1933	1933	1933	1932	1932	1932	1931	1931	1930	1930
	40	1921	1920	1920	1920	1919	1919	1919	1918	1918	1918
	50	1908	1908	1907	1907	1907	1907	1906	1905	1905	1905
59	0	1896	1895	1895	1895	1894	1894	1893	1893	1893	1893
	10	1883	1883	1882	1882	1882	1882	1881	1880	1880	1880
	20	1871	1870	1870	1870	1869	1869	1869	1868	1868	1868
	30	1858	1858	1858	1857	1857	1857	1856	1856	1856	1856
	40	1846	1846	1845	1845	1844	1844	1844	1843	1843	1843
	50	1834	1833	1833	1833	1832	1832	1832	1831	1831	1831
60	0	1822	1821	1821	1820	1820	1820	1819	1819	1819	1819
	10	1809	1809	1808	1808	1808	1808	1807	1806	1806	1806
	20	1797	1797	1796	1796	1795	1795	1795	1794	1794	1794
	30	1785	1784	1784	1784	1783	1783	1783	1782	1782	1782
	40	1773	1772	1772	1771	1771	1771	1770	1770	1770	1770
	50	1761	1760	1760	1759	1759	1759	1758	1758	1758	1758
61	0	1749	1748	1748	1747	1747	1747	1746	1746	1746	1746
	10	1736	1736	1736	1735	1735	1735	1734	1734	1734	1734
	20	1724	1724	1724	1723	1723	1723	1722	1722	1722	1722
	30	1712	1712	1712	1711	1711	1711	1710	1710	1710	1710

TABLE C.
Cor. for Seconds of Parallax.
Add.

Sec.	Cor.
0	12
1	11
2	9
3	8
4	7
5	5
6	4
7	3
8	1
9	0

Sec.	Cor.
0	12
1	11
2	9
3	8
4	7
5	5
6	4
7	3
8	2
9	0

Sec.	Cor.
0	12
1	11
2	9
3	8
4	7
5	6
6	4
7	3
8	2
9	1

Sec.	Cor.
0	12
1	11
2	10
3	8
4	7
5	6
6	5
7	3
8	2
9	1

Digitized by Google

TABLE XIX.

Correction.

App. Alt.	☽'s cen.	☽'s Horizontal Parallax.								Table A. Proportional part for Seconds of Parallax. Add.											Tab. B. For M of Alt. Add.	
D.	M.	54′	55′	56′	57′	58′	59′	60′	61′	S.	0″	1″	2″	3″	4″	5″	6″	7″	8″	9″	M.	S.
80	0	50.19	50. 9	49.58	49.48	49.38	49.27	49.17	49. 6	0	10	10	10	10	9	9	9	9	9	9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
	10	50.28	50.18	50. 8	49.58	49.47	49.37	49.27	49.17	10	8	8	8	8	8	8	7	7	7	7		
	20	50.38	50.27	50.17	50. 7	49.57	49.47	49.37	49.27	20	7	7	6	6	6	6	6	6	5	5		
	30	50.47	50.37	50.27	50.17	50. 7	49.57	49.47	49.37	30	5	5	5	5	4	4	4	4	4	4		
	40	50.56	50.46	50.36	50.27	50.17	50. 7	49.57	49.48	40	3	3	3	3	3	3	2	2	2	2		
	50	51. 5	50.55	50.46	50.36	50.27	50.17	50. 8	49.58	50	2	2	1	1	1	1	1	1	0	0		
81	0	51.15	51. 6	50.56	50.47	50.37	50.28	50.19	50. 9	0	9	9	9	9	8	8	8	8	8	8	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
	10	51.24	51.15	51. 6	50.57	50.47	50.38	50.29	50.20	10	8	7	7	7	7	7	7	6	6	6		
	20	51.33	51.24	51.15	51. 6	50.57	50.48	50.39	50.30	20	6	6	6	6	5	5	5	5	5	5		
	30	51.42	51 34	51.25	51.16	51. 7	50.58	50.49	50.40	30	5	4	4	4	4	4	4	3	3	3		
	40	51.52	51.43	51.34	51.26	51.17	51. 8	50.59	50.51	40	3	3	3	3	2	2	2	2	2	2		
	50	52. 1	51.52	51.44	51.35	51.27	51.18	51.10	51. 1	50	2	1	1	1	1	1	1	0	0	0		
82	0	52.11	52. 3	51.54	51.46	51.38	51.29	51.21	51.13	0	8	8	8	8	7	7	7	7	7	7	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
	10	52.20	52.12	52. 4	51.56	51.47	51.39	51.31	51.23	10	7	7	6	6	6	6	6	6	6	5		
	20	52.29	52.21	52.13	52. 5	51.57	51.49	51.41	51.33	20	5	5	5	5	5	5	5	4	4	4		
	30	52.39	52.31	52.23	52.15	52. 7	51.59	51.52	51.44	30	4	4	4	4	4	3	3	3	3	3		
	40	52.48	52.40	52.32	52.25	52.17	52. 9	52. 2	51.54	40	3	3	2	2	2	2	2	2	2	2		
	50	52.57	52.49	52.42	52.34	52.27	52.19	52.12	52. 4	50	1	1	1	1	1	1	1	0	0	0		
83	0	53. 7	53. 0	52.52	52.45	52.38	52.30	52.23	52.16	0	7	7	7	7	7	6	6	6	6	6	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
	10	53.16	53. 9	53. 2	52.55	52.48	52.41	52.33	52.26	10	6	6	6	6	5	5	5	5	5	5		
	20	53.25	53.18	53.11	53. 5	52.58	52.51	52.44	52.37	20	5	5	4	4	4	4	4	4	4	4		
	30	53.35	53.28	53.21	53.14	53. 7	53. 1	52.54	52.47	30	4	3	3	3	3	3	3	3	3	3		
	40	53.44	53.37	53.31	53.24	53.17	53.11	53. 4	52.57	40	2	2	2	2	2	2	2	2	1	1		
	50	53.53	53.47	53.40	53.34	53.27	53.21	53.14	53. 8	50	1	1	1	1	1	1	1	0	0	0		
84	0	54. 3	53.57	53.51	53.44	53.38	53.32	53.26	53.19	0	6	6	6	6	6	6	5	5	5	5	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
	10	54.12	54. 6	54. 0	53.54	53.48	53.42	53.36	53.30	10	5	5	5	5	5	5	4	4	4	4		
	20	54.22	54.16	54.10	54. 4	53.58	53.52	53.46	53.40	20	4	4	4	4	4	4	3	3	3	3		
	30	54.31	54.25	54.19	54.14	54. 8	54. 2	53.56	53.51	30	3	3	3	3	3	3	2	2	2	2		
	40	54.40	54.35	54.29	54.23	54.18	54.12	54. 7	54. 1	40	2	2	2	2	2	2	2	1	1	1		
	50	54.49	54.44	54.39	54.33	54.28	54.22	54.17	54.11	50	1	1	1	1	1	1	1	0	0	0		
85	0	55. 0	54.54	54.49	54.44	54.39	54.33	54.28	54.23	0	5	5	5	5	5	5	5	4	4	4	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
	10	55. 9	55. 4	54.59	54.54	54.49	54.43	54.38	54.33	10	4	4	4	4	4	4	4	4	4	3		
	20	55.18	55.13	55. 8	55. 3	54.58	54.54	54.49	54.44	20	3	3	3	3	3	3	3	3	3	3		
	30	55.27	55.23	55.18	55.13	55. 8	55. 4	54.59	54.54	30	3	3	2	2	2	2	2	2	2	2		
	40	55.36	55.32	55.27	55.23	55.18	55.14	55. 9	55. 5	40	2	2	2	2	1	1	1	1	1	1		
	50	55.46	55.41	55.37	55.33	55.28	55.24	55.20	55.15	50	1	1	1	1	1	1	1	0	0	0		
86	0	55.56	55.52	55.48	55.43	55.39	55.35	55.31	55.27	0	4	4	4	4	4	4	4	4	4	3	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
	10	56. 5	56. 1	55.57	55.53	55.49	55.45	55.41	55.37	10	3	3	3	3	3	3	3	3	3	3		
	20	56.14	56.11	56. 7	56. 3	55.59	55.55	55.52	55.48	20	3	3	3	3	3	2	2	2	2	2		
	30	56.24	56.20	56.16	56.13	56. 9	56. 5	56. 2	55.58	30	2	2	2	2	2	2	2	2	2	2		
	40	56.33	56.29	56.26	56.22	56.19	56.15	56.12	56. 8	40	2	1	1	1	1	1	1	1	1	1		
	50	56.42	56.39	56.36	56.32	56.29	56.26	56.22	56.19	50	1	1	1	1	1	1	1	0	0	0		
87	0	56.52	56.49	56.46	56.43	56.40	56.37	56.34	56.30	0	3	3	3	3	3	3	3	3	3	3	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
	10	57. 2	56.59	56.56	56.53	56.50	56.47	56.44	56.41	10	3	3	2	2	2	2	2	2	2	2		
	20	57.11	57. 8	57. 5	57. 3	57. 0	56.57	56.54	56.51	20	2	2	2	2	2	2	2	2	2	2		
	30	57.20	57.18	57.15	57.12	57.10	57. 7	57. 4	57. 2	30	2	2	2	2	1	1	1	1	1	1		
	40	57.29	57.27	57.25	57.22	57.20	57.17	57.15	57.12	40	1	1	1	1	1	1	1	1	1	1		
	50	57.39	57.36	57.34	57.32	57.30	57.27	57.25	57.23	50	1	1	1	1	1	1	0	0	0	0		
88	0	57.49	57.47	57.45	57.43	57.41	57.38	57.36	57.34	0	2	2	2	2	2	2	2	2	2	2	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
	10	57.58	57.56	57.54	57.52	57.50	57.49	57.47	57.45	10	2	2	2	2	2	2	2	2	2	1		
	20	58. 7	58. 6	58. 4	58. 2	58. 0	57.59	57.57	57.55	20	1	1	1	1	1	1	1	1	1	1		
	30	58.17	58.15	58.14	58.12	58.10	58. 9	58. 7	58. 6	30	1	1	1	1	1	1	1	1	1	1		
	40	58.26	58.25	58.23	58.22	58.20	58.19	58.18	58.16	40	1	1	1	1	1	1	1	1	1	1		
	50	58.35	58.34	58.33	58.32	58.30	58.29	58.28	58.27	50	1	1	1	1	1	0	0	0	0	0		
89	0	58.45	58.44	58.43	58.42	58.41	58.40	58.39	58.38	0	1	1	1	1	1	1	1	1	1	1	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
	10	58.55	58.54	58.53	58.52	58.51	58.50	58.49	58.49	10	1	1	1	1	1	1	1	1	1	1		
	20	59. 4	59. 3	59. 3	59. 2	59. 1	59. 0	58.59	58.59	20	1	1	1	1	1	1	1	1	1	1		
	30	59.13	59.13	59.12	59.12	59.11	59.11	59.10	59.10	30	1	1	1	1	1	1	1	1	1	1		
	40	59.22	59.22	59.22	59.21	59.21	59.21	59.20	59.20	40	1	1	1	1	1	1	1	1	1	1		
	50	59.32	59.32	59.31	59.31	59.31	59.31	59.31	59.31	50	1	1	1	1	1	0	0	0	0	0		

Digitized by Google

TABLE XIX.

Logarithms.

☽'s Hor. Parallax. M.	S.	Apparent Altitude of ☽'s centre. 80°	81°	82°	83°	84°	85°	86°	87°	88°	89°
54	0	2283	2283	2283	2283	2283	2283	2283	2283	2283	2283
	10	2270	2270	2270	2270	2269	2269	2269	2269	2269	2269
	20	2256	2256	2256	2256	2256	2256	2256	2256	2256	2256
	30	2243	2243	2242	2242	2242	2242	2242	2242	2242	2242
	40	2229	2229	2229	2229	2229	2229	2229	2229	2229	2229
	50	2216	2216	2216	2215	2215	2215	2215	2215	2215	2215
55	0	2202	2202	2202	2202	2202	2202	2202	2202	2202	2202
	10	2189	2189	2189	2189	2189	2189	2189	2189	2188	2188
	20	2176	2175	2175	2175	2175	2175	2175	2175	2175	2175
	30	2162	2162	2162	2162	2162	2162	2162	2162	2162	2162
	40	2149	2149	2149	2149	2149	2149	2149	2149	2149	2149
	50	2136	2136	2136	2136	2136	2135	2135	2135	2135	2135
56	0	2123	2123	2122	2122	2122	2122	2122	2122	2122	2122
	10	2109	2109	2109	2109	2109	2109	2109	2109	2109	2109
	20	2096	2096	2096	2096	2096	2096	2096	2096	2096	2096
	30	2083	2083	2083	2083	2083	2083	2083	2083	2083	2083
	40	2070	2070	2070	2070	2070	2070	2070	2070	2070	2070
	50	2057	2057	2057	2057	2057	2057	2057	2057	2057	2057
57	0	2044	2044	2044	2044	2044	2044	2044	2044	2044	2044
	10	2032	2031	2031	2031	2031	2031	2031	2031	2031	2031
	20	2019	2019	2019	2018	2018	2018	2018	2018	2018	2018
	30	2006	2006	2006	2006	2006	2006	2006	2005	2005	2005
	40	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993
	50	1980	1980	1980	1980	1980	1980	1980	1980	1980	1980
58	0	1968	1968	1967	1967	1967	1967	1967	1967	1967	1967
	10	1955	1955	1955	1955	1955	1955	1955	1955	1955	1955
	20	1942	1942	1942	1942	1942	1942	1942	1942	1942	1942
	30	1930	1930	1930	1930	1929	1929	1929	1929	1929	1929
	40	1917	1917	1917	1917	1917	1917	1917	1917	1917	1917
	50	1905	1905	1904	1904	1904	1904	1904	1904	1904	1904
59	0	1892	1892	1892	1892	1892	1892	1892	1892	1892	1892
	10	1880	1880	1880	1879	1879	1879	1879	1879	1879	1879
	20	1867	1867	1867	1867	1867	1867	1867	1867	1867	1867
	30	1855	1855	1855	1855	1855	1855	1855	1855	1855	1855
	40	1843	1842	1842	1842	1842	1842	1842	1842	1842	1842
	50	1830	1830	1830	1830	1830	1830	1830	1830	1830	1830
60	0	1818	1818	1818	1818	1818	1818	1818	1818	1818	1818
	10	1806	1806	1806	1806	1805	1805	1805	1805	1805	1805
	20	1793	1793	1793	1793	1793	1793	1793	1793	1793	1793
	30	1781	1781	1781	1781	1781	1781	1781	1781	1781	1781
	40	1769	1769	1769	1769	1769	1769	1769	1769	1769	1769
	50	1757	1757	1757	1757	1757	1757	1757	1757	1757	1757
61	0	1745	1745	1745	1745	1745	1745	1745	1745	1745	1745
	10	1733	1733	1733	1733	1733	1733	1733	1733	1733	1733
	20	1721	1721	1721	1721	1721	1721	1721	1721	1721	1721
	30	1709	1709	1709	1709	1709	1709	1709	1709	1709	1709

Table C. Cor. for Seconds of Parallax. Add.

Sec.	Cor.
0	12
1	11
2	9
3	8
4	7
5	5
6	4
7	3
8	1
9	0
Sec.	**Cor.**
0	12
1	11
2	9
3	8
4	7
5	5
6	4
7	3
8	2
9	0
Sec.	**Cor.**
0	12
1	11
2	9
3	8
4	7
5	6
6	4
7	3
8	2
9	1
Sec.	**Cor.**
0	12
1	11
2	10
3	8
4	7
5	6
6	5
7	4
8	2
9	1

17

TABLE XX.

Third Correction of the first method of working a Lunar Observation, *additive*.

☉✱ Alt.	☽ Alt.	*True Distance of the Moon from the Sun or a Star.*														☽ Alt.	☉✱ Alt.
		20°	25°	30°	35°	40°	45°	50°	60°	70°	80°	90°	100°	110°	120°		
10°	10°	96″	79″	67″	60″	53″	48″	41″	37″	31″	27″	23″	19″	15″	11″	10°	10°
	20	66	71	64	58	52	48	43	37	31	27	22	18	15	11	20	
	30	18	39	46	46	44	42	39	34	30	25	22	18	15	13	30	
	40			18	28	32	33	33	30	27	24	21	18	16	15	40	
	50					18	23	25	26	24	22	20	18	17	8	50	
	60							18	22	22	21	19	18	18		60	
	70								18	19	19	18	18			70	
	80									18	18	18				80	
20°	10°	60	64	56	51	46	42	39	33	28	24	20	17	13	10	10°	20°
	20	89	73	63	56	49	44	40	33	28	24	20	17	14	11	20	
	30	67	62	56	50	45	41	38	32	27	23	20	17	15	14	30	
	40	18	35	39	39	38	36	33	29	25	22	19	17	16	18	40	
	50			18	25	28	29	28	26	23	21	19	18	18		50	
	60					18	21	23	23	21	20	18	18			60	
	70							18	20	20	19	18				70	
	80								18	18	18					80	
30°	10°	18	35	40	40	38	36	34	30	26	22	19	16	14	12	10°	30°
	20	66	60	53	49	44	40	36	31	26	22	19	16	15	14	20	
	30	78	64	55	48	43	39	36	30	25	22	19	17	16	18	30	
	40	57	53	48	43	39	36	33	28	24	21	19	17	18		40	
	50	18	31	34	34	32	30	29	25	22	20	18	18			50	
	60			18	23	25	25	24	22	20	19	18				60	
	70					18	20	21	20	19	18					70	
	80							18	19	18						80	
40°	10°			18	26	28	29	29	27	24	21	19	17	15	15	10°	40°
	20	18	34	38	38	36	34	32	28	24	21	19	17	16	18	20	
	30	58	52	47	42	38	35	32	27	24	21	18	17	18		30	
	40	64	54	46	41	37	33	30	26	22	20	18	18			40	
	50	47	43	39	35	32	30	27	24	21	19	18				50	
	60	18	27	28	28	27	25	24	21	19	18					60	
	70			18	21	22	21	21	19	18						70	
	80					18	19	19	18							80	
50°	10°					18	22	23	23	22	20	18	17	17	18	10°	50°
	20			18	25	27	27	27	25	22	20	18	18	18		20	
	30	18	30	33	33	32	30	23	25	22	20	18	18			30	
	40	48	43	39	35	32	30	27	24	21	19	18				40	
	50	50	42	37	33	30	27	25	22	19	18					50	
	60	36	34	31	28	26	24	22	20	18						60	
	70	18	23	23	23	22	21	20	18							70	
	80			18	19	19	19	18								80	
60°	10°							18	20	20	19	18	18	18		10°	60°
	20					18	21	22	22	21	19	18	18			20	
	30			18	23	24	24	24	22	20	19	18				30	
	40	18	26	28	28	27	25	24	21	19	18					40	
	50	36	33	31	28	26	24	22	20	18						50	
	60	36	31	28	25	23	22	20	18							60	
	70	27	25	23	22	20	19	18								70	
	80	18	20	19	19	18										80	
70°	10°								18	19	19	18	18			10°	70°
	20							18	20	19	18	18				20	
	30					18	20	20	20	19	18					30	
	40			18	21	22	21	21	19	18						40	
	50	18	23	23	23	22	21	20	18							50	
	60	27	25	23	22	20	19	18								60	
	70	25	23	21	19	18										70	
	80	20	19	18												80	
80°	10°									18	18	18				10°	80°
	20								18	18	18					20	
	30							18	19	18						30	
	40					18	19	19	18							40	
	50			18	19	19	19	18								50	
	60	18	20	19	19	18										60	
	70	20	19	19												70	
	80	18														80	

In using this Table, it will, in general, be sufficiently accurate, to find the nearest altitudes and distance, and take out the corresponding correction, without the trouble of making a proportion for the neglected degrees and minutes; as in the following examples:—

Example I. Given the apparent distance 47° 34′, the star's apparent altitude 50° 31′, and the moon's apparent altitude 70° 47′, to find the third correction.

Here the Table may be entered with the app. dist. 50°, ✱'s alt. 50°, ☽'s alt. 70°; the corresponding correction is 20″, additive.

Example II. Given the apparent distance 81° 20′, sun's apparent altitude 12° 30′, moon's apparent altitude 20° 38′, to find the third correction.

Here the Table may be entered with the app. dist. 80°, ☉'s alt. 10°, ☽'s alt. 20°; the corresponding correction is 27″.

Digitized by Google

TABLE XXI.

For turning Degrees and Minutes into Time, and the contrary.

D.	H. M.	D.	H. M.	D.	H. M.	D.	H. M.	D.	H. M	D.	H. M.
M.	M. S.	M.	M. S.	M.	M. S.	M.	M. S.	M.	M. S	M.	M. S.
1	0. 4	61	4. 4	121	8. 4	181	12. 4	241	16. 4	301	20. 4
2	0. 8	62	4. 8	122	8. 8	182	12. 8	242	16. 8	302	20. 8
3	0.12	63	4.12	123	8.12	183	12.12	243	16.12	303	20.12
4	0.16	64	4.16	124	8.16	184	12.16	244	16.16	304	20.16
5	0.20	65	4.20	125	8.20	185	12.20	245	16.20	305	20.20
6	0.24	66	4.24	126	8.24	186	12.24	246	16.24	306	20.24
7	0.28	67	4.28	127	8.28	187	12.28	247	16.28	307	20.28
8	0.32	68	4.32	128	8.32	188	12.32	248	16.32	308	20.32
9	0.36	69	4.36	129	8.36	189	12.36	249	16.36	309	20.36
10	0.40	70	4.40	130	8.40	190	12.40	250	16.40	310	20.40
11	0.44	71	4.44	131	8.44	191	12.44	251	16.44	311	20.44
12	0.48	72	4.48	132	8.48	192	12.48	252	16.48	312	20.48
13	0.52	73	4.52	133	8.52	193	12.52	253	16.52	313	20.52
14	0.56	74	4.56	134	8.56	194	12.56	254	16.56	314	20.56
15	1. 0	75	5. 0	135	9. 0	195	13. 0	255	17. 0	315	21. 0
16	1. 4	76	5. 4	136	9. 4	196	13. 4	256	17. 4	316	21. 4
17	1. 8	77	5. 8	137	9. 8	197	13. 8	257	17. 8	317	21. 8
18	1.12	78	5.12	138	9.12	198	13.12	258	17.12	318	21.12
19	1.16	79	5.16	139	9.16	199	13.16	259	17.16	319	21.16
20	1.20	80	5.20	140	9.20	200	13.20	260	17.20	320	21.20
21	1.24	81	5.24	141	9.24	201	13.24	261	17.24	321	21.24
22	1.28	82	5.28	142	9.28	202	13.28	262	17.28	322	21.28
23	1.32	83	5.32	143	9.32	203	13.32	263	17.32	323	21.32
24	1.36	84	5.36	144	9.36	204	13.36	264	17.36	324	21.36
25	1.40	85	5.40	145	9.40	205	13.40	265	17.40	325	21.40
26	1.44	86	5.44	146	9.44	206	13.44	266	17.44	326	21.44
27	1.48	87	5.48	147	9.48	207	13.48	267	17.48	327	21.48
28	1.52	88	5.52	148	9.52	208	13.52	268	17.52	328	21.52
29	1.56	89	5.56	149	9.56	209	13.56	269	17.56	329	21.56
30	2. 0	90	6. 0	150	10. 0	210	14. 0	270	18. 0	330	22. 0
31	2. 4	91	6. 4	151	10. 4	211	14. 4	271	18. 4	331	22. 4
32	2. 8	92	6. 8	152	10. 8	212	14. 8	272	18. 8	332	22. 8
33	2.12	93	6.12	153	10.12	213	14.12	273	18.12	333	22.12
34	2.16	94	6.16	154	10.16	214	14.16	274	18.16	334	22.16
35	2.20	95	6.20	155	10.20	215	14.20	275	18.20	335	22.20
36	2.24	96	6.24	156	10.24	216	14.24	276	18.24	336	22.24
37	2.28	97	6.28	157	10.28	217	14.28	277	18.28	337	22.28
38	2.32	98	6.32	158	10.32	218	14.32	278	18.32	338	22.32
39	2.36	99	6.36	159	10.36	219	14.36	279	18.36	339	22.36
40	2.40	100	6.40	160	10.40	220	14.40	280	18.40	340	22.40
41	2.44	101	6.44	161	10.44	221	14.44	281	18.44	341	22.44
42	2.48	102	6.48	162	10.48	222	14.48	282	18.48	342	22.48
43	2.52	[illegible]	6.52	163	10.52	223	14.52	283	18.52	343	22.52
44	2.56	[illegible]	6.56	164	10.56	224	14.56	284	18.56	344	22.56
45	3. 0	[illegible]	7. 0	165	11. 0	225	15. 0	285	19. 0	345	23. 0
46	3. 4	106	7. 4	166	11. 4	226	15. 4	286	19. 4	346	23. 4
47	3. 8	107	7. 8	167	11. 8	227	15. 8	287	19. 8	347	23. 8
48	3.12	108	7.12	168	11.12	228	15.12	288	19.12	348	23.12
49	3.16	109	7.16	169	11.16	229	15.16	289	19.16	349	23.16
50	3.20	110	7.20	170	11.20	230	15.20	290	19.20	350	23.20
51	3.24	111	7.24	171	11.24	231	15.24	291	19.24	351	23.24
52	3.28	112	7.28	172	11.28	232	15.28	292	19.28	352	23.28
53	3.32	113	7.32	173	11.32	233	15.32	293	19.32	353	23.32
54	3.36	114	7.36	174	11.36	234	15.36	294	19.36	354	23.36
55	3.40	115	7.40	175	11.40	235	15.40	295	19.40	355	23.40
56	3.44	116	7.44	176	11.44	236	15.44	296	19.44	356	23.44
57	3.48	117	7.48	177	11.48	237	15.48	297	19.48	357	23.48
58	3.52	118	7.52	178	11.52	238	15.52	298	19.52	358	23.52
59	3.56	119	7.56	179	11.56	239	15.56	299	19.56	359	23.56
60	4. 0	120	8. 0	180	12. 0	240	16. 0	300	20. 0	360	24. 0

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 0° 0′	h m 0° 1′	h m 0° 2′	h m 0° 3′	h m 0° 4′	h m 0° 5′	h m 0° 6′	h m 0° 7′	h m 0° 8′	S.
0		2.2553	1.9542	1.7782	1.6532	1.5563	1.4771	1.4102	1.3522	0
1	4.0334	2481	9506	7757	6514	5549	4759	4091	3513	1
2	3.7324	2410	9471	7734	6496	5534	4747	4081	3504	2
3	5563	2341	9435	7710	6478	5520	4735	4071	3495	3
4	4314	2272	9400	7686	6460	5506	4723	4061	3486	4
5	3.3345	2.2205	1.9365	1.7663	1.6443	1.5491	1.4711	1.4050	1.3477	5
6	2553	2139	9331	7639	6425	5477	4699	4040	3468	6
7	1883	2073	9296	7616	6407	5463	4688	4030	3459	7
8	1303	2009	9262	7593	6390	5449	4676	4020	3450	8
9	0792	1946	9228	7570	6372	5435	4664	4010	3441	9
10	3.0334	2.1883	1.9195	1.7547	1.6355	1.5421	1.4652	1.4000	1.3432	10
11	2.9920	1822	9162	7524	6338	5407	4640	3989	3423	11
12	9542	1761	9128	7501	6320	5393	4629	3979	3415	12
13	9195	1701	9096	7479	6303	5379	4617	3969	3406	13
14	8873	1642	9063	7456	6286	5365	4606	3959	3397	14
15	2.8573	2.1584	1.9031	1.7434	1.6269	1.5351	1.4594	1.3949	1.3388	15
16	8293	1526	8999	7412	6252	5337	4582	3939	3379	16
17	8030	1469	8967	7390	6235	5324	4571	3929	3371	17
18	7782	1413	8935	7368	6218	5310	4559	3919	3362	18
19	7547	1358	8904	7346	6201	5296	4548	3910	3353	19
20	2.7324	2.1303	1.8873	1.7324	1.6185	1.5283	1.4536	1.3900	1.3345	20
21	7112	1249	8842	7302	6168	5269	4525	3890	3336	21
22	6910	1196	8811	7281	6151	5256	4514	3880	3327	22
23	6717	1143	8781	7259	6135	5242	4502	3870	3319	23
24	6532	1091	8751	7238	6118	5229	4491	3860	3310	24
25	2.6355	2.1040	1.8721	1.7217	1.6102	1.5215	1.4480	1.3851	1.3301	25
26	6185	0989	8691	7196	6085	5202	4468	3841	3293	26
27	6021	0939	8661	7175	6069	5189	4457	3831	3284	27
28	5863	0889	8632	7154	6053	5175	4446	3821	3276	28
29	5710	0840	8602	7133	6037	5162	4435	3812	3267	29
30	2.5563	2.0792	1.8573	1.7112	1.6021	1.5149	1.4424	1.3802	1.3259	30
31	5421	0744	8544	7091	6005	5136	4412	3792	3250	31
32	5283	0696	8516	7071	5989	5123	4401	3783	3242	32
33	5149	0649	8487	7050	5973	5110	4390	3773	3233	33
34	5019	0603	8459	7030	5957	5097	4379	3764	3225	34
35	2.4894	2.0557	1.8431	1.7010	1.5941	1.5084	1.4368	1.3754	1.3216	35
36	4771	0512	8403	6990	5925	5071	4357	3745	3208	36
37	4652	0467	8375	6970	5909	5058	4346	3735	3199	37
38	4536	0422	8348	6950	5894	5045	4335	3726	3191	38
39	4424	0378	8320	6930	5878	5032	4325	3716	3183	39
40	2.4314	2.0334	1.8293	1.6910	1.5863	1.5019	1.4314	1.3707	1.3174	40
41	4206	0291	8266	6890	5847	5007	4303	3697	3166	41
42	4102	0248	8239	6871	5832	4994	4292	3688	3158	42
43	4000	0206	8212	6851	5816	4981	4281	3678	3149	43
44	3900	0164	8186	6832	5801	4969	4270	3669	3141	44
45	2.3802	2.0122	1.8159	1.6812	1.5786	1.4956	1.4260	1.3660	1.3133	45
46	3707	0081	8133	6793	5771	4943	4249	3650	3124	46
47	3613	0040	8107	6774	5755	4931	4238	3641	3116	47
48	3522	0000	8081	6755	5740	4918	4228	3632	3108	48
49	3432	1.9960	8055	6736	5725	4906	4217	3623	3100	49
50	2.3345	1.9920	1.8030	1.6717	1.5710	1.4894	1.4206	1.3613	1.3091	50
51	3259	9881	8004	6698	5695	4881	4196	3604	3083	51
52	3174	9842	7979	6679	5680	4869	4185	3595	3075	52
53	3091	9803	7954	6661	5666	4856	4175	3586	3067	53
54	3010	9765	7929	6642	5651	4844	4164	3576	3059	54
55	2.2931	1.9727	1.7904	1.6624	1.5636	1.4832	1.4154	1.3567	1.3051	55
56	2852	9690	7879	6605	5621	4820	4143	3558	3043	56
57	2775	9652	7855	6587	5607	4808	4133	3549	3034	57
58	2700	9615	7830	6568	5592	4795	4122	3540	3026	58
59	2626	9579	7806	6550	5578	4783	4112	3531	3018	59
S.	0° 0′	0° 1′	0° 2′	0° 3′	0° 4′	0° 5′	0° 6′	0° 7′	0° 8′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 0° 9′	h m 0° 10′	h m 0° 11′	h m 0° 12′	h m 0° 13′	h m 0° 14′	h m 0° 15′	h m 0° 16′	h m 0° 17′	S.
0	1.3010	1.2553	1.2139	1.1761	1.1413	1.1091	1.0792	1.0512	1.0248	0
1	3002	2545	2132	1755	1408	1086	0787	0507	0244	1
2	2994	2538	2126	1749	1402	1081	0782	0502	0240	2
3	2986	2531	2119	1743	1397	1076	0777	0498	0235	3
4	2978	2524	2113	1737	1391	1071	0773	0493	0231	4
5	1.2970	1.2517	1.2106	1.1731	1.1386	1.1066	1.0768	1.0489	1.0227	5
6	2962	2510	2099	1725	1380	1061	0763	0484	0223	6
7	2954	2502	2093	1719	1374	1055	0758	0480	0219	7
8	2946	2495	2086	1713	1369	1050	0753	0475	0214	8
9	2939	2488	2080	1707	1363	1045	0749	0471	0210	9
10	1.2931	1.2481	1.2073	1.1701	1.1358	1.1040	1.0744	1.0467	1.0206	10
11	2923	2474	2067	1695	1352	1035	0739	0462	0202	11
12	2915	2467	2061	1689	1347	1030	0734	0458	0197	12
13	2907	2460	2054	1683	1342	1025	0730	0453	0193	13
14	2899	2453	2048	1677	1336	1020	0725	0449	0189	14
15	1.2891	1.2445	1.2041	1.1671	1.1331	1.1015	1.0720	1.0444	1.0185	15
16	2883	2438	2035	1665	1325	1009	0715	0440	0181	16
17	2876	2431	2028	1660	1320	1004	0711	0435	0176	17
18	2868	2424	2022	1654	1314	0999	0706	0431	0172	18
19	2860	2417	2016	1648	1309	0994	0701	0426	0168	19
20	1.2852	1.2410	1.2009	1.1642	1.1303	1.0989	1.0696	1.0422	1.0164	20
21	2845	2403	2003	1636	1298	0984	0692	0418	0160	21
22	2837	2396	1996	1630	1292	0979	0687	0413	0156	22
23	2829	2389	1990	1624	1287	0974	0682	0409	0151	23
24	2821	2382	1984	1619	1282	0969	0678	0404	0147	24
25	1.2814	1.2375	1.1977	1.1613	1.1276	1.0964	1.0673	1.0400	1.0143	25
26	2806	2368	1971	1607	1271	0959	0668	0395	0139	26
27	2798	2362	1965	1601	1266	0954	0663	0391	0135	27
28	2791	2355	1958	1595	1260	0949	0659	0387	0131	28
29	2783	2348	1952	1589	1255	0944	0654	0382	0126	29
30	1.2775	1.2341	1.1946	1.1584	1.1249	1.0939	1.0649	1.0378	1.0122	30
31	2768	2334	1939	1578	1244	0934	0645	0374	0118	31
32	2760	2327	1933	1572	1239	0929	0640	0369	0114	32
33	2753	2320	1927	1566	1233	0924	0635	0365	0110	33
34	2745	2313	1921	1561	1228	0919	0631	0360	0106	34
35	1.2738	1.2307	1.1914	1.1555	1.1223	1.0914	1.0626	1.0356	1.0102	35
36	2730	2300	1908	1549	1217	0909	0621	0352	0098	36
37	2722	2293	1902	1543	1212	0904	0617	0347	0093	37
38	2715	2286	1896	1538	1207	0899	0612	0343	0089	38
39	2707	2279	1889	1532	1201	0894	0608	0339	0085	39
40	1.2700	1.2272	1.1883	1.1526	1.1196	1.0889	1.0603	1.0334	1.0081	40
41	2692	2266	1877	1520	1191	0884	0598	0330	0077	41
42	2685	2259	1871	1515	1186	0880	0594	0326	0073	42
43	2678	2252	1865	1509	1180	0875	0589	0321	0069	43
44	2670	2245	1859	1503	1175	0870	0585	0317	0065	44
45	1.2663	1.2239	1.1852	1.1498	1.1170	1.0865	1.0580	1.0313	1.0061	45
46	2655	2232	1846	1492	1164	0860	0575	0308	0057	46
47	2648	2225	1840	1486	1159	0855	0571	0304	0053	47
48	2640	2218	1834	1481	1154	0850	0566	0300	0049	48
49	2633	2212	1828	1475	1149	0845	0562	0295	0044	49
50	1.2626	1.2205	1.1822	1.1469	1.1143	1.0840	1.0557	1.0291	1.0040	50
51	2618	2198	1816	1464	1138	0835	0552	0287	0036	51
52	2611	2192	1809	1458	1133	0831	0548	0282	0032	52
53	2604	2185	1803	1452	1128	0826	0543	0278	0028	53
54	2596	2178	1797	1447	1123	0821	0539	0274	0024	54
55	1.2589	1.2172	1.1791	1.1441	1.1117	1.0816	1.0534	1.0270	1.0020	55
56	2582	2165	1785	1436	1112	0811	0530	0265	0016	56
57	2574	2159	1779	1430	1107	0806	0525	0261	0012	57
58	2567	2152	1773	1424	1102	0801	0521	0257	0008	58
59	2560	2145	1767	1419	1097	0797	0516	0252	0004	59
S.	0° 9′	0° 10′	0° 11′	0° 12′	0° 13′	0° 14′	0° 15′	0° 16′	0° 17′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 0° 18′	h m 0° 19′	h m 0° 20′	h m 0° 21′	h m 0° 22′	h m 0° 23′	h m 0° 24′	h m 0° 25′	h m 0° 26′	h m 0° 27′	h m 0° 28′	h m 0° 29′	S.
0	10000	9765	9542	9331	9128	8935	8751	8573	8403	8239	8081	7929	0
1	9996	9761	9539	9327	9125	8932	8748	8570	8400	8236	8079	7926	1
2	9992	9758	9535	9324	9122	8929	8745	8568	8397	8234	8076	7924	2
3	9988	9754	9532	9320	9119	8926	8742	8565	8395	8231	8073	7921	3
4	9984	9750	9528	9317	9115	8923	8739	8562	8392	8228	8071	7919	4
5	9980	9746	9524	9313	9112	8920	8736	8559	8389	8226	8068	7916	5
6	9976	9742	9521	9310	9109	8917	8733	8556	8386	8223	8066	7914	6
7	9972	9739	9517	9306	9106	8913	8730	8553	8384	8220	8063	7911	7
8	9968	9735	9514	9303	9102	8910	8727	8550	8381	8218	8061	7909	8
9	9964	9731	9510	9300	9099	8907	8724	8547	8378	8215	8058	7906	9
10	9960	9727	9506	9296	9096	8904	8721	8544	8375	8212	8055	7904	10
11	9956	9723	9503	9293	9092	8901	8718	8542	8372	8210	8053	7901	11
12	9952	9720	9499	9289	9089	8898	8715	8539	8370	8207	8050	7899	12
13	9948	9716	9496	9286	9086	8895	8712	8536	8367	8204	8048	7896	13
14	9944	9712	9492	9283	9083	8892	8709	8533	8364	8202	8045	7894	14
15	9940	9708	9488	9279	9079	8888	8706	8530	8361	8199	8043	7891	15
16	9936	9705	9485	9276	9076	8885	8703	8527	8359	8196	8040	7889	16
17	9932	9701	9481	9272	9073	8882	8700	8524	8356	8194	8037	7887	17
18	9928	9697	9478	9269	9070	8879	8697	8522	8353	8191	8035	7884	18
19	9924	9693	9474	9266	9066	8876	8694	8519	8350	8188	8032	7882	19
20	9920	9690	9471	9262	9063	8873	8691	8516	8348	8186	8030	7879	20
21	9916	9686	9467	9259	9060	8870	8688	8513	8345	8183	8027	7877	21
22	9912	9682	9464	9255	9057	8867	8685	8510	8342	8181	8025	7874	22
23	9908	9678	9460	9252	9053	8864	8682	8507	8339	8178	8022	7872	23
24	9905	9675	9456	9249	9050	8861	8679	8504	8337	8175	8020	7869	24
25	9901	9671	9453	9245	9047	8857	8676	8502	8334	8173	8017	7867	25
26	9897	9667	9449	9242	9044	8854	8673	8499	8331	8170	8014	7864	26
27	9893	9664	9446	9238	9041	8851	8670	8496	8328	8167	8012	7862	27
28	9889	9660	9442	9235	9037	8848	8667	8493	8326	8165	8009	7859	28
29	9885	9656	9439	9232	9034	8845	8664	8490	8323	8162	8007	7857	29
30	9881	9652	9435	9228	9031	8842	8661	8487	8320	8159	8004	7855	30
31	9877	9649	9432	9225	9028	8839	8658	8484	8318	8157	8002	7852	31
32	9873	9645	9428	9222	9024	8836	8655	8482	8315	8154	7999	7850	32
33	9869	9641	9425	9218	9021	8833	8652	8479	8312	8152	7997	7847	33
34	9865	9638	9421	9215	9018	8830	8649	8476	8309	8149	7994	7845	34
35	9861	9634	9418	9212	9015	8827	8646	8473	8307	8146	7992	7842	35
36	9858	9630	9414	9208	9012	8824	8643	8470	8304	8144	7989	7840	36
37	9854	9626	9411	9205	9008	8821	8640	8467	8301	8141	7987	7837	37
38	9850	9623	9407	9201	9005	8817	8637	8465	8298	8138	7984	7835	38
39	9846	9619	9404	9198	9002	8814	8635	8462	8296	8136	7981	7832	39
40	9842	9615	9400	9195	8999	8811	8632	8459	8293	8133	7979	7830	40
41	9838	9612	9397	9191	8996	8808	8629	8456	8290	8131	7976	7828	41
42	9834	9608	9393	9188	8992	8805	8626	8453	8288	8128	7974	7825	42
43	9830	9604	9390	9185	8989	8802	8623	8451	8285	8125	7971	7823	43
44	9827	9601	9386	9181	8986	8799	8620	8448	8282	8123	7969	7820	44
45	9823	9597	9383	9178	8983	8796	8617	8445	8279	8120	7966	7818	45
46	9819	9593	9379	9175	8980	8793	8614	8442	8277	8117	7964	7815	46
47	9815	9590	9376	9171	8977	8790	8611	8439	8274	8115	7961	7813	47
48	9811	9586	9372	9168	8973	8787	8608	8437	8271	8112	7959	7811	48
49	9807	9582	9369	9165	8970	8784	8605	8434	8269	8110	7956	7808	49
50	9803	9579	9365	9162	8967	8781	8602	8431	8266	8107	7954	7806	50
51	9800	9575	9362	9158	8964	8778	8599	8428	8263	8104	7951	7803	51
52	9796	9571	9358	9155	8961	8775	8597	8425	8261	8102	7949	7801	52
53	9792	9568	9355	9152	8958	8772	8594	8423	8258	8099	7946	7798	53
54	9788	9564	9351	9148	8954	8769	8591	8420	8255	8097	7944	7796	54
55	9784	9561	9348	9145	8951	8766	8588	8417	8253	8094	7941	7794	55
56	9780	9557	9344	9142	8948	8763	8585	8414	8250	8091	7939	7791	56
57	9777	9553	9341	9138	8945	8760	8582	8411	8247	8089	7936	7789	57
58	9773	9550	9337	9135	8942	8757	8579	8409	8244	8086	7934	7786	58
59	9769	9546	9334	9132	8939	8754	8576	8406	8242	8084	7931	7784	59
S.	0° 18′	0° 19′	0° 20′	0° 21′	0° 22′	0° 23′	0° 24′	0° 25′	0° 26′	0° 27′	0° 28′	0° 29′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 0° 30′	h m 0° 31′	h m 0° 32′	h m 0° 33′	h m 0° 34′	h m 0° 35′	h m 0° 36′	h m 0° 37′	h m 0° 38′	h m 0° 39′	h m 0° 40′	h m 0° 41′	S.
0	7782	7639	7501	7368	7238	7112	6990	6871	6755	6642	6532	6425	0
1	7779	7637	7499	7365	7236	7110	6988	6869	6753	6640	6530	6423	1
2	7777	7634	7497	7363	7234	7108	6986	6867	6751	6638	6529	6421	2
3	7774	7632	7494	7361	7232	7106	6984	6865	6749	6637	6527	6420	3
4	7772	7630	7492	7359	7229	7104	6982	6863	6747	6635	6525	6418	4
5	7769	7627	7490	7357	7227	7102	6980	6861	6745	6633	6523	6416	5
6	7767	7625	7488	7354	7225	7100	6978	6859	6743	6631	6521	6414	6
7	7765	7623	7485	7352	7223	7098	6976	6857	6742	6629	6519	6413	7
8	7762	7620	7483	7350	7221	7096	6974	6855	6740	6627	6518	6411	8
9	7760	7618	7481	7348	7219	7093	6972	6853	6738	6625	6516	6409	9
10	7757	7616	7479	7346	7217	7091	6970	6851	6736	6624	6514	6407	10
11	7755	7613	7476	7344	7215	7089	6968	6849	6734	6622	6512	6406	11
12	7753	7611	7474	7341	7212	7087	6966	6847	6732	6620	6510	6404	12
13	7750	7609	7472	7339	7210	7085	6964	6845	6730	6618	6509	6402	13
14	7748	7607	7470	7337	7208	7083	6962	6843	6728	6616	6507	6400	14
15	7745	7604	7467	7335	7206	7081	6960	6841	6726	6614	6505	6398	15
16	7743	7602	7465	7333	7204	7079	6958	6840	6725	6612	6503	6397	16
17	7741	7600	7463	7330	7202	7077	6956	6838	6723	6611	6501	6395	17
18	7738	7597	7461	7328	7200	7075	6954	6836	6721	6609	6500	6393	18
19	7736	7595	7458	7326	7198	7073	6952	6834	6719	6607	6498	6391	19
20	7734	7593	7456	7324	7196	7071	6950	6832	6717	6605	6496	6390	20
21	7731	7590	7454	7322	7193	7069	6948	6830	6715	6603	6494	6388	21
22	7729	7588	7452	7320	7191	7067	6946	6828	6713	6601	6492	6386	22
23	7726	7586	7450	7317	7189	7065	6944	6826	6711	6600	6491	6384	23
24	7724	7583	7447	7315	7187	7063	6942	6824	6709	6598	6489	6383	24
25	7722	7581	7445	7313	7185	7061	6940	6822	6708	6596	6487	6381	25
26	7719	7579	7443	7311	7183	7059	6938	6820	6706	6594	6485	6379	26
27	7717	7577	7441	7309	7181	7057	6936	6818	6704	6592	6484	6377	27
28	7714	7574	7438	7307	7179	7055	6934	6816	6702	6590	6482	6376	28
29	7712	7572	7436	7304	7177	7052	6932	6814	6700	6589	6480	6374	29
30	7710	7570	7434	7302	7175	7050	6930	6812	6698	6587	6478	6372	30
31	7707	7567	7432	7300	7172	7048	6928	6810	6696	6585	6476	6371	31
32	7705	7565	7429	7298	7170	7046	6926	6809	6694	6583	6475	6369	32
33	7703	7563	7427	7296	7168	7044	6924	6807	6692	6581	6473	6367	33
34	7700	7560	7425	7294	7166	7042	6922	6805	6691	6579	6471	6365	34
35	7698	7558	7423	7291	7164	7040	6920	6803	6689	6578	6469	6364	35
36	7696	7556	7421	7289	7162	7038	6918	6801	6687	6576	6467	6362	36
37	7693	7554	7418	7287	7160	7036	6916	6799	6685	6574	6466	6360	37
38	7691	7551	7416	7285	7158	7034	6914	6797	6683	6572	6464	6358	38
39	7688	7549	7414	7283	7156	7032	6912	6795	6681	6570	6462	6357	39
40	7686	7547	7412	7281	7154	7030	6910	6793	6679	6568	6460	6355	40
41	7684	7544	7409	7279	7152	7028	6908	6791	6677	6567	6459	6353	41
42	7681	7542	7407	7276	7149	7026	6906	6789	6676	6565	6457	6351	42
43	7679	7540	7405	7274	7147	7024	6904	6787	6674	6563	6455	6350	43
44	7677	7538	7403	7272	7145	7022	6902	6785	6672	6561	6453	6348	44
45	7674	7535	7401	7270	7143	7020	6900	6784	6670	6559	6451	6346	45
46	7672	7533	7398	7268	7141	7018	6898	6782	6668	6558	6450	6344	46
47	7670	7531	7396	7266	7139	7016	6896	6780	6666	6556	6448	6343	47
48	7667	7528	7394	7264	7137	7014	6894	6778	6664	6554	6446	6341	48
49	7665	7526	7392	7261	7135	7012	6892	6776	6663	6552	6444	6339	49
50	7663	7524	7390	7259	7133	7010	6890	6774	6661	6550	6443	6338	50
51	7660	7522	7387	7257	7131	7008	6888	6772	6659	6548	6441	6336	51
52	7658	7519	7385	7255	7129	7006	6886	6770	6657	6547	6439	6334	52
53	7655	7517	7383	7253	7127	7004	6884	6768	6655	6545	6437	6332	53
54	7653	7515	7381	7251	7124	7002	6882	6766	6653	6543	6435	6331	54
55	7651	7513	7379	7249	7122	7000	6881	6764	6651	6541	6434	6329	55
56	7648	7510	7376	7246	7120	6998	6879	6763	6650	6539	6432	6327	56
57	7646	7508	7374	7244	7118	6996	6877	6761	6648	6538	6430	6325	57
58	7644	7506	7372	7242	7116	6994	6875	6759	6646	6536	6428	6324	58
59	7641	7503	7370	7240	7114	6992	6873	6757	6644	6534	6427	6322	59
S.	0° 30′	0° 31′	0° 32′	0° 33′	0° 34′	0° 35′	0° 36′	0° 37′	0° 38′	0° 39′	0° 40′	0° 41′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 0° 42′	h m 0° 43′	h m 0° 44′	h m 0° 45′	h m 0° 46′	h m 0° 47′	h m 0° 48′	h m 0° 49′	h m 0° 50	h m 0° 51′	h m 0° 52′	h m 0° 53′	S.
0	6320	6218	6118	6021	5925	5832	5740	5651	5563	5477	5393	5310	0
1	6319	6216	6117	6019	5924	5830	5739	5649	5562	5476	5391	5309	1
2	6317	6215	6115	6017	5922	5829	5737	5648	5560	5474	5390	5307	2
3	6315	6213	6113	6016	5920	5827	5736	5646	5559	5473	5389	5306	3
4	6313	6211	6112	6014	5919	5826	5734	5645	5557	5471	5387	5305	4
5	6312	6210	6110	6013	5917	5824	5733	5643	5556	5470	5386	5303	5
6	6310	6208	6108	6011	5916	5823	5731	5642	5554	5469	5384	5302	6
7	6308	6206	6107	6009	5914	5821	5730	5640	5553	5467	5383	5300	7
8	6306	6205	6105	6008	5913	5819	5728	5639	5551	5466	5382	5299	8
9	6305	6203	6103	6006	5911	5818	5727	5637	5550	5464	5380	5298	9
10	6303	6201	6102	6005	5909	5816	5725	5636	5549	5463	5379	5296	10
11	6301	6200	6100	6003	5908	5815	5724	5635	5547	5461	5377	5295	11
12	6300	6198	6099	6001	5906	5813	5722	5633	5546	5460	5376	5294	12
13	6298	6196	6097	6000	5905	5812	5721	5632	5544	5459	5375	5292	13
14	6296	6195	6095	5998	5903	5810	5719	5630	5543	5457	5373	5291	14
15	6294	6193	6094	5997	5902	5809	5718	5629	5541	5456	5372	5290	15
16	6293	6191	6092	5995	5900	5807	5716	5627	5540	5454	5370	5288	16
17	6291	6190	6090	5993	5898	5806	5715	5626	5538	5453	5369	5287	17
18	6289	6188	6089	5992	5897	5804	5713	5624	5537	5452	5368	5285	18
19	6288	6186	6087	5990	5895	5803	5712	5623	5536	5450	5366	5284	19
20	6286	6185	6085	5989	5894	5801	5710	5621	5534	5449	5365	5283	20
21	6284	6183	6084	5987	5892	5800	5709	5620	5533	5447	5364	5281	21
22	6282	6181	6082	5985	5891	5798	5707	5618	5531	5446	5362	5280	22
23	6281	6179	6081	5984	5889	5796	5706	5617	5530	5445	5361	5279	23
24	6279	6178	6079	5982	5888	5795	5704	5615	5528	5443	5359	5277	24
25	6277	6176	6077	5981	5886	5793	5703	5614	5527	5442	5358	5276	25
26	6276	6174	6076	5979	5884	5792	5701	5613	5526	5440	5357	5275	26
27	6274	6173	6074	5977	5883	5790	5700	5611	5524	5439	5355	5273	27
28	6272	6171	6072	5976	5881	5789	5698	5610	5523	5437	5354	5272	28
29	6271	6169	6071	5974	5880	5787	5697	5608	5521	5436	5353	5271	29
30	6269	6168	6069	5973	5878	5786	5695	5607	5520	5435	5351	5269	30
31	6267	6166	6067	5971	5877	5784	5694	5605	5518	5433	5350	5268	31
32	6265	6165	6066	5969	5875	5783	5692	5604	5517	5432	5348	5266	32
33	6264	6163	6064	5968	5874	5781	5691	5602	5516	5430	5347	5265	33
34	6262	6161	6063	5966	5872	5780	5689	5601	5514	5429	5346	5264	34
35	6260	6160	6061	5965	5870	5778	5688	5599	5513	5428	5344	5262	35
36	6259	6158	6059	5963	5869	5777	5686	5598	5511	5426	5343	5261	36
37	6257	6156	6058	5961	5867	5775	5685	5596	5510	5425	5341	5260	37
38	6255	6155	6056	5960	5866	5774	5683	5595	5508	5423	5340	5258	38
39	6254	6153	6055	5958	5864	5772	5682	5594	5507	5422	5339	5257	39
40	6252	6151	6053	5957	5863	5771	5680	5592	5506	5421	5337	5256	40
41	6250	6150	6051	5955	5861	5769	5679	5591	5504	5419	5336	5254	41
42	6248	6148	6050	5954	5860	5768	5677	5589	5503	5418	5335	5253	42
43	6247	6146	6048	5952	5858	5766	5676	5588	5501	5416	5333	5252	43
44	6245	6145	6046	5950	5856	5765	5674	5586	5500	5415	5332	5250	44
45	6243	6143	6045	5949	5855	5763	5673	5585	5498	5414	5331	5249	45
46	6242	6141	6043	5947	5853	5761	5671	5583	5497	5412	5329	5248	46
47	6240	6140	6042	5946	5852	5760	5670	5582	5496	5411	5328	5246	47
48	6238	6138	6040	5944	5850	5758	5669	5580	5494	5409	5326	5245	48
49	6237	6136	6038	5942	5849	5757	5667	5579	5493	5408	5325	5244	49
50	6235	6135	6037	5941	5847	5755	5666	5578	5491	5407	5324	5242	50
51	6233	6133	6035	5939	5846	5754	5664	5576	5490	5405	5322	5241	51
52	6232	6131	6033	5938	5844	5752	5663	5575	5488	5404	5321	5240	52
53	6230	6130	6032	5936	5843	5751	5661	5573	5487	5402	5320	5238	53
54	6228	6128	6030	5935	5841	5749	5660	5572	5486	5401	5318	5237	54
55	6226	6126	6029	5933	5839	5748	5658	5570	5484	5400	5317	5235	55
56	6225	6125	6027	5931	5838	5746	5657	5569	5483	5398	5315	5234	56
57	6223	6123	6025	5930	5836	5745	5655	5567	5481	5397	5314	5233	57
58	6221	6121	6024	5928	5835	5743	5654	5566	5480	5395	5313	5231	58
59	6220	6120	6022	5927	5833	5742	5652	5564	5478	5394	5311	5230	59
S.	0° 42′	0° 43′	0° 44′	0° 45′	0° 46′	0° 47′	0° 48′	0° 49′	0° 50′	0° 51′	0° 52′	0° 53′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 0° 54′	h m 0° 55′	h m 0° 56′	h m 0° 57′	h m 0° 58′	h m 0° 59′	h m 1° 0′	h m 1° 1′	h m 1° 2′	h m 1° 3′	h m 1° 4′	h m 1° 5′	S.
0	5229	5149	5071	4994	4918	4844	4771	4699	4629	4559	4491	4424	0
1	5227	5148	5070	4993	4917	4843	4770	4698	4628	4558	4490	4422	1
2	5226	5146	5068	4991	4916	4842	4769	4697	4626	4557	4489	4421	2
3	5225	5145	5067	4990	4915	4841	4768	4696	4625	4556	4488	4420	3
4	5223	5144	5066	4989	4913	4839	4766	4695	4624	4555	4486	4419	4
5	5222	5143	5064	4988	4912	4838	4765	4693	4623	4554	4485	4418	5
6	5221	5141	5063	4986	4911	4837	4764	4692	4622	4552	4484	4417	6
7	5219	5140	5062	4985	4910	4836	4763	4691	4621	4551	4483	4416	7
8	5218	5139	5061	4984	4908	4834	4762	4690	4619	4550	4482	4415	8
9	5217	5137	5059	4983	4907	4833	4760	4689	4618	4549	4481	4414	9
10	5215	5136	5058	4981	4906	4832	4759	4688	4617	4548	4480	4412	10
11	5214	5135	5057	4980	4905	4831	4758	4686	4616	4547	4479	4411	11
12	5213	5133	5055	4979	4903	4830	4757	4685	4615	4546	4477	4410	12
13	5211	5132	5054	4977	4902	4828	4756	4684	4614	4544	4476	4409	13
14	5210	5131	5053	4976	4901	4827	4754	4683	4612	4543	4475	4408	14
15	5209	5129	5051	4975	4900	4826	4753	4682	4611	4542	4474	4407	15
16	5207	5128	5050	4974	4899	4825	4752	4680	4610	4541	4473	4406	16
17	5206	5127	5049	4972	4897	4823	4751	4679	4609	4540	4472	4405	17
18	5205	5125	5048	4971	4896	4822	4750	4678	4608	4539	4471	4404	18
19	5203	5124	5046	4970	4895	4821	4748	4677	4607	4538	4469	4402	19
20	5202	5123	5045	4969	4894	4820	4747	4676	4606	4536	4468	4401	20
21	5201	5122	5044	4967	4892	4819	4746	4675	4604	4535	4467	4400	21
22	5199	5120	5043	4966	4891	4817	4745	4673	4603	4534	4466	4399	22
23	5198	5119	5041	4965	4890	4816	4744	4672	4602	4533	4465	4398	23
24	5197	5118	5040	4964	4889	4815	4742	4671	4601	4532	4464	4397	24
25	5195	5116	5039	4962	4887	4814	4741	4670	4600	4531	4463	4396	25
26	5194	5115	5037	4961	4886	4812	4740	4669	4599	4530	4462	4395	26
27	5193	5114	5036	4960	4885	4811	4739	4668	4597	4528	4460	4394	27
28	5191	5112	5035	4959	4884	4810	4738	4666	4596	4527	4459	4393	28
29	5190	5111	5034	4957	4882	4809	4736	4665	4595	4526	4458	4391	29
30	5189	5110	5032	4956	4881	4808	4735	4664	4594	4525	4457	4390	30
31	5187	5108	5031	4955	4880	4806	4734	4663	4593	4524	4456	4389	31
32	5186	5107	5030	4954	4879	4805	4733	4662	4592	4523	4455	4388	32
33	5185	5106	5028	4952	4877	4804	4732	4660	4590	4522	4454	4387	33
34	5183	5105	5027	4951	4876	4803	4730	4659	4589	4520	4453	4386	34
35	5182	5103	5026	4950	4875	4801	4729	4658	4588	4519	4452	4385	35
36	5181	5102	5025	4949	4874	4800	4728	4657	4587	4518	4450	4384	36
37	5179	5101	5023	4947	4873	4799	4727	4656	4586	4517	4449	4383	37
38	5178	5099	5022	4946	4871	4798	4726	4655	4585	4516	4448	4381	38
39	5177	5098	5021	4945	4870	4797	4724	4653	4584	4515	4447	4380	39
40	5175	5097	5019	4943	4869	4795	4723	4652	4582	4514	4446	4379	40
41	5174	5095	5018	4942	4868	4794	4722	4651	4581	4512	4445	4378	41
42	5173	5094	5017	4941	4866	4793	4721	4650	4580	4511	4444	4377	42
43	5172	5093	5016	4940	4865	4792	4720	4649	4579	4510	4443	4376	43
44	5170	5092	5014	4938	4864	4791	4718	4648	4578	4509	4441	4375	44
45	5169	5090	5013	4937	4863	4789	4717	4646	4577	4508	4440	4374	45
46	5168	5089	5012	4936	4861	4788	4716	4645	4575	4507	4439	4373	46
47	5166	5088	5011	4935	4860	4787	4715	4644	4574	4506	4438	4372	47
48	5165	5086	5009	4933	4859	4786	4714	4643	4573	4505	4437	4370	48
49	5164	5085	5008	4932	4858	4785	4712	4642	4572	4503	4436	4369	49
50	5162	5084	5007	4931	4856	4783	4711	4640	4571	4502	4435	4368	50
51	5161	5082	5005	4930	4855	4782	4710	4639	4570	4501	4434	4367	51
52	5160	5081	5004	4928	4854	4781	4709	4638	4569	4500	4433	4366	52
53	5158	5080	5003	4927	4853	4780	4708	4637	4567	4499	4431	4365	53
54	5157	5079	5002	4926	4852	4778	4707	4636	4566	4498	4430	4364	54
55	5156	5077	5000	4925	4850	4777	4705	4635	4565	4497	4429	4363	55
56	5154	5076	4999	4923	4849	4776	4704	4633	4564	4495	4428	4362	56
57	5153	5075	4998	4922	4848	4775	4703	4632	4563	4494	4427	4361	57
58	5152	5073	4997	4921	4847	4774	4702	4631	4562	4493	4426	4359	58
59	5150	5072	4995	4920	4845	4772	4701	4630	4560	4492	4425	4358	59
S	0° 54′	0° 55′	0° 56′	0° 57′	0° 58′	0° 59′	1° 0′	1° 1′	1° 2′	1° 3′	1° 4′	1° 5′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 1° 6'	h m 1° 7'	h m 1° 8'	h m 1° 9'	h m 1° 10'	h m 1° 11'	h m 1° 12'	h m 1° 13'	h m 1° 14'	h m 1° 15'	h m 1° 16'	h m 1° 17'	S.
0	4357	4292	4228	4164	4102	4040	3979	3919	3860	3802	3745	3688	0
1	4356	4291	4227	4163	4101	4039	3978	3919	3859	3801	3744	3687	1
2	4355	4290	4226	4162	4100	4038	3977	3918	3858	3800	3743	3686	2
3	4354	4289	4224	4161	4099	4037	3976	3917	3857	3799	3742	3685	3
4	4353	4288	4223	4160	4098	4036	3975	3916	3856	3798	3741	3684	4
5	4352	4287	4222	4159	4097	4035	3974	3915	3856	3797	3740	3683	5
6	4351	4285	4221	4158	4096	4034	3973	3914	3855	3796	3739	3682	6
7	4350	4284	4220	4157	4095	4033	3972	3913	3854	3795	3738	3681	7
8	4349	4283	4219	4156	4093	4032	3971	3912	3853	3794	3737	3680	8
9	4347	4282	4218	4155	4092	4031	3970	3911	3852	3793	3736	3679	9
10	4346	4281	4217	4154	4091	4030	3969	3910	3851	3792	3735	3678	10
11	4345	4280	4216	4153	4090	4029	3968	3909	3850	3792	3734	3677	11
12	4344	4279	4215	4152	4089	4028	3967	3908	3849	3791	3733	3677	12
13	4343	4278	4214	4151	4088	4027	3966	3907	3848	3790	3732	3676	13
14	4342	4277	4213	4150	4087	4026	3965	3906	3847	3789	3731	3675	14
15	4341	4276	4212	4149	4086	4025	3964	3905	3846	3788	3730	3674	15
16	4340	4275	4211	4147	4085	4024	3963	3904	3845	3787	3729	3673	16
17	4339	4274	4210	4146	4084	4023	3962	3903	3844	3786	3728	3672	17
18	4338	4273	4209	4145	4083	4022	3961	3902	3843	3785	3727	3671	18
19	4336	4271	4207	4144	4082	4021	3960	3901	3842	3784	3727	3670	19
20	4335	4270	4206	4143	4081	4020	3959	3900	3841	3783	3726	3669	20
21	4334	4269	4205	4142	4080	4019	3958	3899	3840	3782	3725	3668	21
22	4333	4268	4204	4141	4079	4018	3957	3898	3839	3781	3724	3667	22
23	4332	4267	4203	4140	4078	4017	3956	3897	3838	3780	3723	3666	23
24	4331	4266	4202	4139	4077	4016	3955	3896	3837	3779	3722	3665	24
25	4330	4265	4201	4138	4076	4015	3954	3895	3836	3778	3721	3664	25
26	4329	4264	4200	4137	4075	4014	3953	3894	3835	3777	3720	3663	26
27	4328	4263	4199	4136	4074	4013	3952	3893	3834	3776	3719	3663	27
28	4327	4262	4198	4135	4073	4012	3951	3892	3833	3775	3718	3662	28
29	4326	4261	4197	4134	4072	4011	3950	3891	3832	3774	3717	3661	29
30	4325	4260	4196	4133	4071	4010	3949	3890	3831	3773	3716	3660	30
31	4323	4259	4195	4132	4070	4009	3948	3889	3830	3772	3715	3659	31
32	4322	4258	4194	4131	4069	4008	3947	3888	3829	3771	3714	3658	32
33	4321	4256	4193	4130	4068	4007	3946	3887	3828	3770	3713	3657	33
34	4320	4255	4192	4129	4067	4006	3945	3886	3827	3769	3712	3656	34
35	4319	4254	4191	4128	4066	4005	3944	3885	3826	3768	3711	3655	35
36	4318	4253	4189	4127	4065	4004	3943	3884	3825	3768	3710	3654	36
37	4317	4252	4188	4126	4064	4003	3942	3883	3824	3767	3709	3653	37
38	4316	4251	4187	4125	4063	4002	3941	3882	3823	3766	3709	3652	38
39	4315	4250	4186	4124	4062	4001	3940	3881	3822	3765	3708	3651	39
40	4314	4249	4185	4122	4061	4000	3939	3880	3821	3764	3707	3650	40
41	4313	4248	4184	4121	4060	3999	3938	3879	3820	3763	3706	3649	41
42	4311	4247	4183	4120	4059	3998	3937	3878	3820	3762	3705	3649	42
43	4310	4246	4182	4119	4058	3997	3936	3877	3819	3761	3704	3648	43
44	4309	4245	4181	4118	4056	3996	3935	3876	3818	3760	3703	3647	44
45	4308	4244	4180	4117	4055	3995	3934	3875	3817	3759	3702	3646	45
46	4307	4243	4179	4116	4054	3993	3933	3874	3816	3758	3701	3645	46
47	4306	4241	4178	4115	4053	3992	3932	3873	3815	3757	3700	3644	47
48	4305	4240	4177	4114	4052	3991	3931	3872	3814	3756	3699	3643	48
49	4304	4239	4176	4113	4051	3990	3930	3871	3813	3755	3698	3642	49
50	4303	4238	4175	4112	4050	3989	3929	3870	3812	3754	3697	3641	50
51	4302	4237	4174	4111	4049	3988	3928	3869	3811	3753	3696	3640	51
52	4301	4236	4173	4110	4048	3987	3927	3868	3810	3752	3695	3639	52
53	4300	4235	4172	4109	4047	3986	3926	3867	3809	3751	3694	3638	53
54	4298	4234	4171	4108	4046	3985	3925	3866	3808	3750	3693	3637	54
55	4297	4233	4169	4107	4045	3984	3924	3865	3807	3749	3693	3636	55
56	4296	4232	4168	4106	4044	3983	3923	3864	3806	3748	3692	3635	56
57	4295	4231	4167	4105	4043	3982	3922	3863	3805	3747	3691	3635	57
58	4294	4230	4166	4104	4042	3981	3921	3862	3804	3746	3690	3634	58
59	4293	4229	4165	4103	4041	3980	3920	3861	3803	3746	3689	3633	59
S.	1° 6'	1° 7'	1° 8'	1° 9'	1° 10'	1° 11'	1° 12'	1° 13'	1° 14'	1° 15'	1° 16'	1° 17'	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 1° 18′	h m 1° 19′	h m 1° 20′	h m 1° 21′	h m 1° 22′	h m 1° 23′	h m 1° 24′	h m 1° 25′	h m 1° 26′	h m 1° 27′	h m 1° 28′	h m 1° 29′	S.
0	3632	3576	3522	3468	3415	3362	3310	3259	3208	3158	3108	3059	0
1	3631	3576	3521	3467	3414	3361	3309	3258	3207	3157	3107	3058	1
2	3630	3575	3520	3466	3413	3360	3308	3257	3206	3156	3106	3057	2
3	3629	3574	3519	3465	3412	3359	3307	3256	3205	3155	3105	3056	3
4	3628	3573	3518	3464	3411	3358	3306	3255	3204	3154	3105	3056	4
5	3627	3572	3517	3463	3410	3358	3306	3254	3204	3153	3104	3055	5
6	3626	3571	3516	3463	3409	3357	3305	3253	3203	3153	3103	3054	6
7	3625	3570	3515	3462	3408	3356	3304	3253	3202	3152	3102	3053	7
8	3624	3569	3515	3461	3408	3355	3303	3252	3201	3151	3101	3052	8
9	3623	3568	3514	3460	3407	3354	3302	3251	3200	3150	3101	3052	9
10	3623	3567	3513	3459	3406	3353	3301	3250	3199	3149	3100	3051	10
11	3622	3566	3512	3458	3405	3352	3300	3249	3198	3148	3099	3050	11
12	3621	3565	3511	3457	3404	3351	3300	3248	3198	3148	3098	3049	12
13	3620	3565	3510	3456	3403	3351	3299	3247	3197	3147	3097	3048	13
14	3619	3564	3509	3455	3402	3350	3298	3247	3196	3146	3096	3047	14
15	3618	3563	3508	3454	3401	3349	3297	3246	3195	3145	3096	3047	15
16	3617	3562	3507	3454	3400	3348	3296	3245	3194	3144	3095	3046	16
17	3616	3561	3506	3453	3400	3347	3295	3244	3193	3143	3094	3045	17
18	3615	3560	3506	3452	3399	3346	3294	3243	3193	3143	3093	3044	18
19	3614	3559	3505	3451	3398	3345	3294	3242	3192	3142	3092	3043	19
20	3613	3558	3504	3450	3397	3345	3293	3242	3191	3141	3091	3043	20
21	3612	3557	3503	3449	3396	3344	3292	3241	3190	3140	3091	3042	21
22	3611	3556	3502	3448	3395	3343	3291	3240	3189	3139	3090	3041	22
23	3610	3555	3501	3447	3394	3342	3290	3239	3188	3138	3089	3040	23
24	3610	3555	3500	3446	3393	3341	3289	3238	3188	3138	3088	3039	24
25	3609	3554	3499	3446	3393	3340	3288	3237	3187	3137	3087	3039	25
26	3608	3553	3498	3445	3392	3339	3288	3236	3186	3136	3087	3038	26
27	3607	3552	3497	3444	3391	3338	3287	3236	3185	3135	3086	3037	27
28	3606	3551	3497	3443	3390	3338	3286	3235	3184	3134	3085	3036	28
29	3605	3550	3496	3442	3389	3337	3285	3234	3183	3133	3084	3035	29
30	3604	3549	3495	3441	3388	3336	3284	3233	3183	3133	3083	3034	30
31	3603	3548	3494	3440	3387	3335	3283	3232	3182	3132	3082	3034	31
32	3602	3547	3493	3439	3386	3334	3282	3231	3181	3131	3082	3033	32
33	3601	3546	3492	3438	3386	3333	3282	3231	3180	3130	3081	3032	33
34	3600	3545	3491	3438	3385	3332	3281	3230	3179	3129	3080	3031	34
35	3599	3545	3490	3437	3384	3332	3280	3229	3178	3129	3079	3030	35
36	3598	3544	3489	3436	3383	3331	3279	3228	3178	3128	3078	3030	36
37	3598	3543	3488	3435	3382	3330	3278	3227	3177	3127	3078	3029	37
38	3597	3542	3488	3434	3381	3329	3277	3226	3176	3126	3077	3028	38
39	3596	3541	3487	3433	3380	3328	3276	3225	3175	3125	3076	3027	39
40	3595	3540	3486	3432	3379	3327	3276	3225	3174	3124	3075	3026	40
41	3594	3539	3485	3431	3379	3326	3275	3224	3173	3124	3074	3026	41
42	3593	3538	3484	3431	3378	3325	3274	3223	3173	3123	3073	3025	42
43	3592	3537	3483	3430	3377	3325	3273	3222	3172	3122	3073	3024	43
44	3591	3536	3482	3429	3376	3324	3272	3221	3171	3121	3072	3023	44
45	3590	3535	3481	3428	3375	3323	3271	3220	3170	3120	3071	3022	45
46	3589	3535	3480	3427	3374	3322	3270	3220	3169	3119	3070	3022	46
47	3588	3534	3480	3426	3373	3321	3270	3219	3168	3119	3069	3021	47
48	3587	3533	3479	3425	3372	3320	3269	3218	3168	3118	3069	3020	48
49	3587	3532	3478	3424	3372	3319	3268	3217	3167	3117	3068	3019	49
50	3586	3531	3477	3423	3371	3319	3267	3216	3166	3116	3067	3018	50
51	3585	3530	3476	3423	3370	3318	3266	3215	3165	3115	3066	3018	51
52	3584	3529	3475	3422	3369	3317	3265	3214	3164	3114	3065	3017	52
53	3583	3528	3474	3421	3368	3316	3265	3214	3163	3114	3065	3016	53
54	3582	3527	3473	3420	3367	3315	3264	3213	3163	3113	3064	3015	54
55	3581	3526	3472	3419	3366	3314	3263	3212	3162	3112	3063	3014	55
56	3580	3525	3471	3418	3365	3313	3262	3211	3161	3111	3062	3014	56
57	3579	3525	3471	3417	3365	3313	3261	3210	3160	3110	3061	3013	57
58	3578	3524	3470	3416	3364	3312	3260	3209	3159	3110	3060	3012	58
59	3577	3523	3469	3415	3363	3311	3259	3209	3158	3109	3060	3011	59
S.	1° 18′	1° 19′	1° 20′	1° 21′	1° 22′	1° 23′	1° 24′	1° 25′	1° 26′	1° 27′	1° 28′	1° 29′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 1° 30′	h m 1° 31′	h m 1° 32′	h m 1° 33′	h m 1° 34′	h m 1° 35′	h m 1° 36′	h m 1° 37′	h m 1° 38′	h m 1° 39′	h m 1° 40′	h m 1° 41′	S.
0	3010	2962	2915	2868	2821	2775	2730	2685	2640	2596	2553	2510	0
1	3009	2962	2914	2867	2821	2775	2729	2684	2640	2596	2552	2509	1
2	3009	2961	2913	2866	2820	2774	2729	2684	2639	2595	2551	2508	2
3	3008	2960	2912	2866	2819	2773	2728	2683	2638	2594	2551	2507	3
4	3007	2959	2912	2865	2818	2772	2727	2682	2638	2593	2550	2507	4
5	3006	2958	2911	2864	2818	2772	2726	2681	2637	2593	2549	2506	5
6	3005	2958	2910	2863	2817	2771	2725	2681	2636	2592	2548	2505	6
7	3005	2957	2909	2862	2816	2770	2725	2680	2635	2591	2548	2504	7
8	3004	2956	2909	2862	2815	2769	2724	2679	2635	2591	2547	2504	8
9	3003	2955	2908	2861	2815	2769	2723	2678	2634	2590	2546	2503	9
10	3002	2954	2907	2860	2814	2768	2722	2678	2633	2589	2545	2502	10
11	3001	2954	2906	2859	2813	2767	2722	2677	2632	2588	2545	2502	11
12	3001	2953	2905	2859	2812	2766	2721	2676	2632	2588	2544	2501	12
13	3000	2952	2905	2858	2811	2766	2720	2675	2631	2587	2543	2500	13
14	2999	2951	2904	2857	2811	2765	2719	2675	2630	2586	2543	2499	14
15	2998	2950	2903	2856	2810	2764	2719	2674	2629	2585	2542	2499	15
16	2997	2950	2902	2855	2809	2763	2718	2673	2629	2585	2541	2498	16
17	2997	2949	2901	2855	2808	2763	2717	2672	2628	2584	2540	2497	17
18	2996	2948	2901	2854	2808	2762	2716	2672	2627	2583	2540	2497	18
19	2995	2947	2900	2853	2807	2761	2716	2671	2626	2583	2539	2496	19
20	2994	2946	2899	2852	2806	2760	2715	2670	2626	2582	2538	2495	20
21	2993	2946	2898	2852	2805	2760	2714	2669	2625	2581	2538	2494	21
22	2993	2945	2898	2851	2805	2759	2713	2669	2624	2580	2537	2494	22
23	2992	2944	2897	2850	2804	2758	2713	2668	2624	2580	2536	2493	23
24	2991	2943	2896	2849	2803	2757	2712	2667	2623	2579	2535	2492	24
25	2990	2942	2895	2848	2802	2756	2711	2666	2622	2578	2535	2492	25
26	2989	2942	2894	2848	2801	2756	2710	2666	2621	2577	2534	2491	26
27	2989	2941	2894	2847	2801	2755	2710	2665	2621	2577	2533	2490	27
28	2988	2940	2893	2846	2800	2754	2709	2664	2620	2576	2533	2489	28
29	2987	2939	2892	2845	2799	2753	2708	2663	2619	2575	2532	2489	29
30	2986	2939	2891	2845	2798	2753	2707	2663	2618	2574	2531	2488	30
31	2985	2938	2891	2844	2798	2752	2707	2662	2618	2574	2530	2487	31
32	2985	2937	2890	2843	2797	2751	2706	2661	2617	2573	2530	2487	32
33	2984	2936	2889	2842	2796	2750	2705	2660	2616	2572	2529	2486	33
34	2983	2935	2888	2842	2795	2750	2704	2660	2615	2572	2528	2485	34
35	2982	2935	2887	2841	2795	2749	2704	2659	2615	2571	2527	2485	35
36	2981	2934	2887	2840	2794	2748	2703	2658	2614	2570	2527	2484	36
37	2981	2933	2886	2839	2793	2747	2702	2657	2613	2569	2526	2483	37
38	2980	2932	2885	2838	2792	2747	2701	2657	2612	2569	2525	2482	38
39	2979	2931	2884	2838	2792	2746	2701	2656	2612	2568	2525	2482	39
40	2978	2931	2883	2837	2791	2745	2700	2655	2611	2567	2524	2481	40
41	2977	2930	2883	2836	2790	2744	2699	2655	2610	2566	2523	2480	41
42	2977	2929	2882	2835	2789	2744	2698	2654	2610	2566	2522	2480	42
43	2976	2928	2881	2835	2788	2743	2698	2653	2609	2565	2522	2479	43
44	2975	2927	2880	2834	2788	2742	2697	2652	2608	2564	2521	2478	44
45	2974	2927	2880	2833	2787	2741	2696	2652	2607	2564	2520	2477	45
46	2973	2926	2879	2832	2786	2741	2695	2651	2607	2563	2520	2477	46
47	2973	2925	2878	2831	2785	2740	2695	2650	2606	2562	2519	2476	47
48	2972	2924	2877	2831	2785	2739	2694	2649	2605	2561	2518	2475	48
49	2971	2924	2876	2830	2784	2738	2693	2649	2604	2561	2517	2475	49
50	2970	2923	2876	2829	2783	2738	2692	2648	2604	2560	2517	2474	50
51	2969	2922	2875	2828	2782	2737	2692	2647	2603	2559	2516	2473	51
52	2969	2921	2874	2828	2782	2736	2691	2646	2602	2559	2515	2472	52
53	2968	2920	2873	2827	2781	2735	2690	2646	2601	2558	2515	2472	53
54	2967	2920	2873	2826	2780	2735	2689	2645	2601	2557	2514	2471	54
55	2966	2919	2872	2825	2779	2734	2689	2644	2600	2556	2513	2470	55
56	2965	2918	2871	2825	2779	2733	2688	2643	2599	2556	2512	2470	56
57	2965	2917	2870	2824	2778	2732	2687	2643	2599	2555	2512	2469	57
58	2964	2916	2869	2823	2777	2732	2687	2642	2598	2554	2511	2468	58
59	2963	2916	2869	2822	2776	2731	2686	2641	2597	2553	2510	2467	59
S.	1° 30′	1° 31′	1° 32′	1° 33′	1° 34′	1° 35′	1° 36′	1° 37′	1° 38′	1° 39′	1° 40′	1° 41′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 1° 42′	h m 1° 43′	h m 1° 44′	h m 1° 45′	h m 1° 46′	h m 1° 47′	h m 1° 48′	h m 1° 49′	h m 1° 50′	h m 1° 51′	h m 1° 52′	h m 1° 53′	S.
0	2467	2424	2382	2341	2300	2259	2218	2178	2139	2099	2061	2022	0
1	2466	2424	2382	2340	2299	2258	2218	2178	2138	2099	2060	2021	1
2	2465	2423	2381	2339	2298	2258	2217	2177	2137	2098	2059	2021	2
3	2465	2422	2380	2339	2298	2257	2216	2176	2137	2098	2059	2020	3
4	2464	2422	2380	2338	2297	2256	2216	2176	2136	2097	2058	2019	4
5	2463	2421	2379	2337	2296	2256	2215	2175	2136	2096	2057	2019	5
6	2462	2420	2378	2337	2296	2255	2214	2174	2135	2096	2057	2018	6
7	2462	2419	2378	2336	2295	2254	2214	2174	2134	2095	2056	2017	7
8	2461	2419	2377	2335	2294	2253	2213	2173	2134	2094	2056	2017	8
9	2460	2418	2376	2335	2294	2253	2212	2172	2133	2094	2055	2016	9
10	2460	2417	2375	2334	2293	2252	2212	2172	2132	2093	2054	2016	10
11	2459	2417	2375	2333	2292	2251	2211	2171	2132	2092	2053	2015	11
12	2458	2416	2374	2333	2291	2251	2210	2170	2131	2092	2053	2014	12
13	2458	2415	2373	2332	2291	2250	2210	2170	2130	2091	2052	2014	13
14	2457	2415	2373	2331	2290	2249	2209	2169	2130	2090	2052	2013	14
15	2456	2414	2372	2331	2289	2249	2208	2169	2129	2090	2051	2012	15
16	2455	2413	2371	2330	2289	2248	2208	2168	2128	2089	2050	2012	16
17	2455	2412	2371	2329	2288	2247	2207	2167	2128	2088	2050	2011	17
18	2454	2412	2370	2328	2287	2247	2206	2167	2127	2088	2049	2010	18
19	2453	2411	2369	2328	2287	2246	2206	2166	2126	2087	2048	2010	19
20	2453	2410	2368	2327	2286	2245	2205	2165	2126	2086	2048	2009	20
21	2452	2410	2368	2326	2285	2245	2204	2165	2125	2086	2047	2009	21
22	2451	2409	2367	2326	2285	2244	2204	2164	2124	2085	2046	2008	22
23	2450	2408	2366	2325	2284	2243	2203	2163	2124	2085	2046	2007	23
24	2450	2408	2366	2324	2283	2243	2202	2163	2123	2084	2045	2007	24
25	2449	2407	2365	2324	2283	2242	2202	2162	2122	2083	2044	2006	25
26	2448	2406	2364	2323	2282	2241	2201	2161	2122	2083	2044	2005	26
27	2448	2405	2364	2322	2281	2241	2200	2161	2121	2082	2043	2005	27
28	2447	2405	2363	2322	2281	2240	2200	2160	2120	2081	2042	2004	28
29	2446	2404	2362	2321	2280	2239	2199	2159	2120	2081	2042	2003	29
30	2445	2403	2362	2320	2279	2239	2198	2159	2119	2080	2041	2003	30
31	2445	2403	2361	2320	2279	2238	2198	2158	2118	2079	2041	2002	31
32	2444	2402	2360	2319	2278	2237	2197	2157	2118	2079	2040	2001	32
33	2443	2401	2359	2318	2277	2237	2196	2157	2117	2078	2039	2001	33
34	2443	2401	2359	2317	2277	2236	2196	2156	2116	2077	2039	2000	34
35	2442	2400	2358	2317	2276	2235	2195	2155	2116	2077	2038	2000	35
36	2441	2399	2357	2316	2275	2235	2194	2155	2115	2076	2037	1999	36
37	2441	2398	2357	2315	2274	2234	2194	2154	2115	2075	2037	1998	37
38	2440	2398	2356	2315	2274	2233	2193	2153	2114	2075	2036	1998	38
39	2439	2397	2355	2314	2273	2233	2192	2153	2113	2074	2035	1997	39
40	2438	2396	2355	2313	2272	2232	2192	2152	2113	2073	2035	1996	40
41	2438	2396	2354	2313	2272	2231	2191	2151	2112	2073	2034	1996	41
42	2437	2395	2353	2312	2271	2231	2190	2151	2111	2072	2033	1995	42
43	2436	2394	2353	2311	2270	2230	2190	2150	2111	2072	2033	1994	43
44	2436	2394	2352	2311	2270	2229	2189	2149	2110	2071	2032	1994	44
45	2435	2393	2351	2310	2269	2229	2188	2149	2109	2070	2032	1993	45
46	2434	2392	2350	2309	2268	2228	2188	2148	2109	2070	2031	1993	46
47	2433	2391	2350	2309	2268	2227	2187	2147	2108	2069	2030	1992	47
48	2433	2391	2349	2308	2267	2227	2186	2147	2107	2068	2030	1991	48
49	2432	2390	2348	2307	2266	2226	2186	2146	2107	2068	2029	1991	49
50	2431	2389	2348	2307	2266	2225	2185	2145	2106	2067	2028	1990	50
51	2431	2389	2347	2306	2265	2225	2184	2145	2105	2066	2028	1989	51
52	2430	2388	2346	2305	2264	2224	2184	2144	2105	2066	2027	1989	52
53	2429	2387	2346	2304	2264	2223	2183	2143	2104	2065	2026	1988	53
54	2429	2387	2345	2304	2263	2223	2182	2143	2103	2064	2026	1987	54
55	2428	2386	2344	2303	2262	2222	2182	2142	2103	2064	2025	1987	55
56	2427	2385	2344	2302	2262	2221	2181	2141	2102	2063	2025	1986	56
57	2426	2384	2343	2302	2261	2220	2180	2141	2101	2062	2024	1986	57
58	2426	2384	2342	2301	2260	2220	2180	2140	2101	2062	2023	1985	58
59	2425	2383	2342	2300	2260	2219	2179	2139	2100	2061	2023	1984	59
S.	1° 42′	1° 43′	1° 44′	1° 45′	1° 46′	1° 47′	1° 48′	1° 49′	1° 50′	1° 51′	1° 52′	1° 53′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 1° 54′	h m 1° 55′	h m 1° 56′	h m 1° 57′	h m 1° 58′	h m 1° 59′	h m 2° 0′	h m 2° 1′	h m 2° 2′	h m 2° 3′	h m 2° 4′	S.
0	1984	1946	1908	1871	1834	1797	1761	1725	1689	1654	1619	0
1	1983	1945	1908	1870	1833	1797	1760	1724	1689	1653	1618	1
2	1982	1944	1907	1870	1833	1796	1760	1724	1688	1652	1617	2
3	1982	1944	1906	1869	1832	1795	1759	1723	1687	1652	1617	3
4	1981	1943	1906	1868	1831	1795	1759	1722	1687	1651	1616	4
5	1981	1943	1905	1868	1831	1794	1758	1722	1686	1651	1616	5
6	1980	1942	1904	1867	1830	1794	1757	1721	1686	1650	1615	6
7	1979	1941	1904	1867	1830	1793	1757	1721	1685	1650	1614	7
8	1979	1941	1903	1866	1829	1792	1756	1720	1684	1649	1614	8
9	1978	1940	1903	1865	1828	1792	1755	1719	1684	1648	1613	9
10	1977	1939	1902	1865	1828	1791	1755	1719	1683	1648	1613	10
11	1977	1939	1901	1864	1827	1791	1754	1718	1683	1647	1612	11
12	1976	1938	1901	1863	1827	1790	1754	1718	1682	1647	1612	12
13	1975	1938	1900	1863	1826	1789	1753	1717	1681	1646	1611	13
14	1975	1937	1899	1862	1825	1789	1752	1717	1681	1645	1610	14
15	1974	1936	1899	1862	1825	1788	1752	1716	1680	1645	1610	15
16	1974	1936	1898	1861	1824	1788	1751	1715	1680	1644	1609	16
17	1973	1935	1898	1860	1823	1787	1751	1715	1679	1644	1609	17
18	1972	1934	1897	1860	1823	1786	1750	1714	1678	1643	1608	18
19	1972	1934	1896	1859	1822	1786	1749	1714	1678	1643	1607	19
20	1971	1933	1896	1859	1822	1785	1749	1713	1677	1642	1607	20
21	1970	1933	1895	1858	1821	1785	1748	1712	1677	1641	1606	21
22	1970	1932	1894	1857	1820	1784	1748	1712	1676	1641	1606	22
23	1969	1931	1894	1857	1820	1783	1747	1711	1676	1640	1605	23
24	1968	1931	1893	1856	1819	1783	1746	1711	1675	1640	1605	24
25	1968	1930	1893	1855	1819	1782	1746	1710	1674	1639	1604	25
26	1967	1929	1892	1855	1818	1781	1745	1709	1674	1638	1603	26
27	1967	1929	1891	1854	1817	1781	1745	1709	1673	1638	1603	27
28	1966	1928	1891	1854	1817	1780	1744	1708	1673	1637	1602	28
29	1965	1928	1890	1853	1816	1780	1743	1708	1672	1637	1602	29
30	1965	1927	1889	1852	1816	1779	1743	1707	1671	1636	1601	30
31	1964	1926	1889	1852	1815	1778	1742	1706	1671	1635	1600	31
32	1963	1926	1888	1851	1814	1778	1742	1706	1670	1635	1600	32
33	1963	1925	1888	1850	1814	1777	1741	1705	1670	1634	1599	33
34	1962	1924	1887	1850	1813	1777	1740	1705	1669	1634	1599	34
35	1962	1924	1886	1849	1812	1776	1740	1704	1668	1633	1598	35
36	1961	1923	1886	1849	1812	1775	1739	1703	1668	1633	1598	36
37	1960	1923	1885	1848	1811	1775	1739	1703	1667	1632	1597	37
38	1960	1922	1884	1847	1811	1774	1738	1702	1667	1631	1596	38
39	1959	1921	1884	1847	1810	1774	1737	1702	1666	1631	1596	39
40	1958	1921	1883	1846	1809	1773	1737	1701	1665	1630	1595	40
41	1958	1920	1883	1846	1809	1772	1736	1700	1665	1630	1595	41
42	1957	1919	1882	1845	1808	1772	1736	1700	1664	1629	1594	42
43	1956	1919	1881	1844	1808	1771	1735	1699	1664	1628	1593	43
44	1956	1918	1881	1844	1807	1771	1734	1699	1663	1628	1593	44
45	1955	1918	1880	1843	1806	1770	1734	1698	1663	1627	1592	45
46	1955	1917	1880	1843	1806	1769	1733	1697	1662	1627	1592	46
47	1954	1916	1879	1842	1805	1769	1733	1697	1661	1626	1591	47
48	1953	1916	1878	1841	1805	1768	1732	1696	1661	1626	1591	48
49	1953	1915	1878	1841	1804	1768	1731	1696	1660	1625	1590	49
50	1952	1914	1877	1840	1803	1767	1731	1695	1660	1624	1589	50
51	1951	1914	1876	1839	1803	1766	1730	1694	1659	1624	1589	51
52	1951	1913	1876	1839	1802	1766	1730	1694	1658	1623	1588	52
53	1950	1913	1875	1838	1802	1765	1729	1693	1658	1623	1588	53
54	1950	1912	1875	1838	1801	1765	1728	1693	1657	1622	1587	54
55	1949	1911	1874	1837	1800	1764	1728	1692	1657	1621	1587	55
56	1948	1911	1873	1836	1800	1763	1727	1692	1656	1621	1586	56
57	1948	1910	1873	1836	1799	1763	1727	1691	1655	1620	1585	57
58	1947	1909	1872	1835	1798	1762	1726	1690	1655	1620	1585	58
59	1946	1909	1871	1835	1798	1762	1725	1690	1654	1619	1584	59
S.	1° 54′	1° 55′	1° 56′	1° 57′	1° 58′	1° 59′	2° 0′	2° 1′	2° 2′	2° 3′	2° 4′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 2° 5′	h m 2° 6′	h m 2° 7′	h m 2° 8′	h m 2° 9′	h m 2° 10′	h m 2° 11′	h m 2° 12′	h m 2° 13′	h m 2° 14′	h m 2° 15′	S.
0	1584	1549	1515	1481	1447	1413	1380	1347	1314	1282	1249	0
1	1583	1548	1514	1480	1446	1413	1379	1346	1314	1281	1249	1
2	1582	1548	1514	1479	1446	1412	1379	1346	1313	1281	1248	2
3	1582	1547	1513	1479	1445	1412	1378	1345	1313	1280	1248	3
4	1581	1547	1512	1478	1445	1411	1378	1345	1312	1280	1247	4
5	1581	1546	1512	1478	1444	1411	1377	1344	1311	1279	1247	5
6	1580	1546	1511	1477	1443	1410	1377	1344	1311	1278	1246	6
7	1580	1545	1511	1477	1443	1409	1376	1343	1310	1278	1246	7
8	1579	1544	1510	1476	1442	1409	1376	1343	1310	1277	1245	8
9	1578	1544	1510	1476	1442	1408	1375	1342	1309	1277	1245	9
10	1578	1543	1509	1475	1441	1408	1374	1342	1309	1276	1244	10
11	1577	1543	1508	1474	1441	1407	1374	1341	1308	1275	1243	11
12	1577	1542	1508	1474	1440	1407	1373	1340	1308	1275	1243	12
13	1576	1542	1507	1473	1440	1406	1373	1340	1307	1275	1242	13
14	1576	1541	1507	1473	1439	1406	1372	1339	1307	1274	1242	14
15	1575	1540	1506	1472	1438	1405	1372	1339	1306	1274	1241	15
16	1574	1540	1506	1472	1438	1404	1371	1338	1306	1273	1241	16
17	1574	1539	1505	1471	1437	1404	1371	1338	1305	1273	1240	17
18	1573	1539	1504	1470	1437	1403	1370	1337	1304	1272	1240	18
19	1573	1538	1504	1470	1436	1403	1370	1337	1304	1271	1239	19
20	1572	1538	1503	1469	1436	1402	1369	1336	1303	1271	1239	20
21	1571	1537	1503	1469	1435	1402	1368	1335	1303	1270	1238	21
22	1571	1536	1502	1468	1435	1401	1368	1335	1302	1270	1238	22
23	1570	1536	1502	1468	1434	1401	1367	1334	1302	1269	1237	23
24	1570	1535	1501	1467	1433	1400	1367	1334	1301	1269	1237	24
25	1569	1535	1500	1467	1433	1399	1366	1333	1301	1268	1236	25
26	1569	1534	1500	1466	1432	1399	1366	1333	1300	1268	1235	26
27	1568	1534	1499	1465	1432	1398	1365	1332	1300	1267	1235	27
28	1567	1533	1499	1465	1431	1398	1365	1332	1299	1267	1234	28
29	1567	1532	1498	1464	1431	1397	1364	1331	1298	1266	1234	29
30	1566	1532	1498	1464	1430	1397	1363	1331	1298	1266	1233	30
31	1566	1531	1497	1463	1429	1396	1363	1330	1297	1265	1233	31
32	1565	1531	1496	1463	1429	1396	1362	1329	1297	1264	1232	32
33	1565	1530	1496	1462	1428	1395	1362	1329	1296	1264	1232	33
34	1564	1530	1495	1461	1428	1394	1361	1328	1296	1263	1231	34
35	1563	1529	1495	1461	1427	1394	1361	1328	1295	1263	1231	35
36	1563	1528	1494	1460	1427	1393	1360	1327	1295	1262	1230	36
37	1562	1528	1494	1460	1426	1393	1360	1327	1294	1262	1230	37
38	1562	1527	1493	1459	1426	1392	1359	1326	1294	1261	1229	38
39	1561	1527	1493	1459	1425	1392	1359	1326	1293	1261	1229	39
40	1561	1526	1492	1458	1424	1391	1358	1325	1292	1260	1228	40
41	1560	1526	1491	1458	1424	1391	1357	1325	1292	1260	1227	41
42	1559	1525	1491	1457	1423	1390	1357	1324	1291	1259	1227	42
43	1559	1524	1490	1456	1423	1389	1356	1323	1291	1259	1226	43
44	1558	1524	1490	1456	1422	1389	1356	1323	1290	1258	1226	44
45	1558	1523	1489	1455	1422	1388	1355	1322	1290	1257	1225	45
46	1557	1523	1489	1455	1421	1388	1355	1322	1289	1257	1225	46
47	1556	1522	1488	1454	1421	1387	1354	1321	1289	1256	1224	47
48	1556	1522	1487	1454	1420	1387	1354	1321	1288	1256	1224	48
49	1555	1521	1487	1453	1419	1386	1353	1320	1288	1255	1223	49
50	1555	1520	1486	1452	1419	1386	1352	1320	1287	1255	1223	50
51	1554	1520	1486	1452	1418	1385	1352	1319	1287	1254	1222	51
52	1554	1519	1485	1451	1418	1384	1351	1319	1286	1254	1222	52
53	1553	1519	1485	1451	1417	1384	1351	1318	1285	1253	1221	53
54	1552	1518	1484	1450	1417	1383	1350	1317	1285	1253	1221	54
55	1552	1518	1483	1450	1416	1383	1350	1317	1284	1252	1220	55
56	1551	1517	1483	1449	1416	1382	1349	1316	1284	1252	1219	56
57	1551	1516	1482	1449	1415	1382	1349	1316	1283	1251	1219	57
58	1550	1516	1482	1448	1414	1381	1348	1315	1283	1250	1218	58
59	1550	1515	1481	1447	1414	1381	1348	1315	1282	1250	1218	59
S.	2° 5′	2° 6′	2° 7′	2° 8′	2° 9′	2° 10′	2° 11′	2° 12′	2° 13′	2° 14′	2° 15′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 2° 16′	h m 2° 17′	h m 2° 18′	h m 2° 19′	h m 2° 20′	h m 2° 21′	h m 2° 22′	h m 2° 23′	h m 2° 24′	h m 2° 25′	h m 2° 26′	S.
0	1217	1186	1154	1123	1091	1061	1030	0999	0969	0939	0909	0
1	1217	1185	1153	1122	1091	1060	1029	0999	0969	0939	0909	1
2	1216	1184	1153	1122	1090	1060	1029	0998	0968	0938	0908	2
3	1216	1184	1152	1121	1090	1059	1028	0998	0968	0938	0908	3
4	1215	1183	1152	1120	1089	1058	1028	0997	0967	0937	0907	4
5	1215	1183	1151	1120	1089	1058	1027	0997	0967	0937	0907	5
6	1214	1182	1151	1119	1088	1057	1027	0996	0966	0936	0906	6
7	1214	1182	1150	1119	1088	1057	1026	0996	0966	0936	0906	7
8	1213	1181	1150	1118	1087	1056	1026	0995	0965	0935	0905	8
9	1213	1181	1149	1118	1087	1056	1025	0995	0965	0935	0905	9
10	1212	1180	1149	1117	1086	1055	1025	0994	0964	0934	0904	10
11	1211	1180	1148	1117	1086	1055	1024	0994	0964	0934	0904	11
12	1211	1179	1148	1116	1085	1054	1024	0993	0963	0933	0903	12
13	1210	1179	1147	1116	1085	1054	1023	0993	0963	0933	0903	13
14	1210	1178	1147	1115	1084	1053	1023	0992	0962	0932	0902	14
15	1209	1178	1146	1115	1084	1053	1022	0992	0962	0932	0902	15
16	1209	1177	1146	1114	1083	1052	1022	0991	0961	0931	0901	16
17	1208	1177	1145	1114	1083	1052	1021	0991	0961	0931	0901	17
18	1208	1176	1145	1113	1082	1051	1021	0990	0960	0930	0900	18
19	1207	1175	1144	1113	1082	1051	1020	0990	0960	0930	0900	19
20	1207	1175	1143	1112	1081	1050	1020	0989	0959	0929	0899	20
21	1206	1174	1143	1112	1081	1050	1019	0989	0959	0929	0899	21
22	1206	1174	1142	1111	1080	1049	1019	0988	0958	0928	0898	22
23	1205	1173	1142	1111	1080	1049	1018	0988	0958	0928	0898	23
24	1205	1173	1141	1110	1079	1048	1018	0987	0957	0927	0897	24
25	1204	1172	1141	1110	1079	1048	1017	0987	0957	0927	0897	25
26	1204	1172	1140	1109	1078	1047	1017	0986	0956	0926	0896	26
27	1203	1171	1140	1109	1078	1047	1016	0986	0956	0926	0896	27
28	1202	1171	1139	1108	1077	1046	1016	0985	0955	0925	0895	28
29	1202	1170	1139	1108	1076	1046	1015	0985	0955	0925	0895	29
30	1201	1170	1138	1107	1076	1045	1015	0984	0954	0924	0894	30
31	1201	1169	1138	1106	1075	1045	1014	0984	0954	0924	0894	31
32	1200	1169	1137	1106	1075	1044	1014	0983	0953	0923	0893	32
33	1200	1168	1137	1105	1074	1044	1013	0983	0953	0923	0893	33
34	1199	1168	1136	1105	1074	1043	1013	0982	0952	0922	0892	34
35	1199	1167	1136	1104	1073	1043	1012	0982	0952	0922	0892	35
36	1198	1167	1135	1104	1073	1042	1012	0981	0951	0921	0891	36
37	1198	1166	1135	1103	1072	1042	1011	0981	0951	0921	0891	37
38	1197	1165	1134	1103	1072	1041	1011	0980	0950	0920	0890	38
39	1197	1165	1134	1102	1071	1041	1010	0980	0950	0920	0890	39
40	1196	1164	1133	1102	1071	1040	1009	0979	0949	0919	0889	40
41	1196	1164	1132	1101	1070	1040	1009	0979	0949	0919	0889	41
42	1195	1163	1132	1101	1070	1039	1008	0978	0948	0918	0888	42
43	1195	1163	1131	1100	1069	1039	1008	0978	0948	0918	0888	43
44	1194	1162	1131	1100	1069	1038	1007	0977	0947	0917	0887	44
45	1193	1162	1130	1099	1068	1037	1007	0977	0947	0917	0887	45
46	1193	1161	1130	1099	1068	1037	1006	0976	0946	0916	0886	46
47	1192	1161	1129	1098	1067	1036	1006	0976	0946	0916	0886	47
48	1192	1160	1129	1098	1067	1036	1005	0975	0945	0915	0885	48
49	1191	1160	1128	1097	1066	1035	1005	0975	0945	0915	0885	49
50	1191	1159	1128	1097	1066	1035	1004	0974	0944	0914	0884	50
51	1190	1159	1127	1096	1065	1034	1004	0974	0944	0914	0884	51
52	1190	1158	1127	1096	1065	1034	1003	0973	0943	0913	0883	52
53	1189	1158	1126	1095	1064	1033	1003	0973	0943	0913	0883	53
54	1189	1157	1126	1095	1064	1033	1002	0972	0942	0912	0883	54
55	1188	1157	1125	1094	1063	1032	1002	0972	0942	0912	0882	55
56	1188	1156	1125	1094	1063	1032	1001	0971	0941	0911	0882	56
57	1187	1156	1124	1093	1062	1031	1001	0971	0941	0911	0881	57
58	1187	1155	1124	1092	1062	1031	1000	0970	0940	0910	0881	58
59	1186	1154	1123	1092	1061	1030	1000	0970	0940	0910	0880	59
S.	2° 16′	2° 17′	2° 18′	2° 19′	2° 20′	2° 21′	2° 22′	2° 23′	2° 24′	2° 25′	2° 26′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms

S	h m 2° 27′	h m 2° 28′	h m 2° 29′	h m 2° 30′	h m 2° 31′	h m 2° 32′	h m 2° 33′	h m 2° 34′	h m 2° 35′	h m 2° 36′	h m 2° 37′	S.
0	0880	0850	0821	0792	0763	0734	0706	0678	0649	0621	0594	0
1	0879	0850	0820	0791	0762	0734	0705	0677	0649	0621	0593	1
2	0879	0849	0820	0791	0762	0733	0705	0677	0648	0621	0593	2
3	0878	0849	0819	0790	0762	0733	0704	0676	0648	0620	0592	3
4	0878	0848	0819	0790	0761	0732	0704	0676	0648	0620	0592	4
5	0877	0848	0818	0789	0761	0732	0703	0675	0647	0619	0591	5
6	0877	0847	0818	0789	0760	0731	0703	0675	0647	0619	0591	6
7	0876	0847	0817	0788	0760	0731	0703	0674	0646	0618	0591	7
8	0876	0846	0817	0788	0759	0730	0702	0674	0646	0618	0590	8
9	0875	0846	0816	0787	0759	0730	0702	0673	0645	0617	0590	9
10	0875	0845	0816	0787	0758	0730	0701	0673	0645	0617	0589	10
11	0874	0845	0816	0787	0758	0729	0701	0672	0644	0616	0589	11
12	0874	0844	0815	0786	0757	0729	0700	0672	0644	0616	0588	12
13	0873	0844	0815	0786	0757	0728	0700	0671	0643	0615	0588	13
14	0873	0843	0814	0785	0756	0728	0699	0671	0643	0615	0587	14
15	0872	0843	0814	0785	0756	0727	0699	0670	0642	0615	0587	15
16	0872	0842	0813	0784	0755	0727	0698	0670	0642	0614	0586	16
17	0871	0842	0813	0784	0755	0726	0698	0670	0641	0614	0586	17
18	0871	0841	0812	0783	0754	0726	0697	0669	0641	0613	0585	18
19	0870	0841	0812	0783	0754	0725	0697	0669	0641	0613	0585	19
20	0870	0840	0811	0782	0753	0725	0696	0668	0640	0612	0585	20
21	0869	0840	0811	0782	0753	0724	0696	0668	0640	0612	0584	21
22	0869	0839	0810	0781	0752	0724	0695	0667	0639	0611	0584	22
23	0868	0839	0810	0781	0752	0723	0695	0667	0639	0611	0583	23
24	0868	0838	0809	0780	0751	0723	0694	0666	0638	0610	0583	24
25	0867	0838	0809	0780	0751	0722	0694	0666	0638	0610	0582	25
26	0867	0837	0808	0779	0751	0722	0694	0665	0637	0609	0582	26
27	0866	0837	0808	0779	0750	0721	0693	0665	0637	0609	0581	27
28	0866	0836	0807	0778	0750	0721	0693	0664	0636	0609	0581	28
29	0865	0836	0807	0778	0749	0721	0692	0664	0635	0608	0580	29
30	0865	0835	0806	0777	0749	0720	0692	0663	0635	0608	0580	30
31	0864	0835	0806	0777	0748	0720	0691	0663	0635	0607	0579	31
32	0864	0834	0805	0776	0748	0719	0691	0663	0634	0607	0579	32
33	0863	0834	0805	0776	0747	0719	0690	0662	0634	0605	0579	33
34	0863	0834	0804	0775	0747	0718	0690	0662	0634	0606	0578	34
35	0862	0833	0804	0775	0746	0718	0689	0661	0633	0605	0578	35
36	0862	0833	0803	0774	0746	0717	0689	0661	0633	0605	0577	36
37	0861	0832	0803	0774	0745	0717	0688	0660	0632	0604	0577	37
38	0861	0832	0802	0774	0745	0716	0688	0660	0632	0604	0576	38
39	0860	0831	0802	0773	0744	0716	0687	0659	0631	0603	0576	39
40	0860	0831	0801	0773	0744	0715	0687	0659	0631	0603	0575	40
41	0859	0830	0801	0772	0743	0715	0686	0658	0630	0602	0575	41
42	0859	0830	0801	0772	0743	0714	0686	0658	0630	0602	0574	42
43	0858	0829	0800	0771	0742	0714	0686	0657	0629	0602	0574	43
44	0858	0829	0800	0771	0742	0713	0685	0657	0629	0601	0573	44
45	0857	0828	0799	0770	0741	0713	0685	0656	0628	0601	0573	45
46	0857	0828	0799	0770	0741	0712	0684	0656	0628	0600	0573	46
47	0856	0827	0798	0769	0740	0712	0684	0655	0628	0600	0572	47
48	0856	0827	0798	0769	0740	0711	0683	0655	0627	0599	0572	48
49	0855	0826	0797	0768	0740	0711	0683	0655	0627	0599	0571	49
50	0855	0826	0797	0768	0739	0711	0682	0654	0626	0598	0571	50
51	0855	0825	0796	0767	0739	0710	0682	0654	0626	0598	0570	51
52	0854	0825	0796	0767	0738	0710	0681	0653	0625	0597	0570	52
53	0854	0824	0795	0766	0738	0709	0681	0653	0625	0597	0569	53
54	0853	0824	0795	0766	0737	0709	0680	0652	0624	0596	0569	54
55	0853	0823	0794	0765	0737	0708	0680	0652	0624	0596	0568	55
56	0852	0823	0794	0765	0736	0708	0679	0651	0623	0596	0568	56
57	0852	0822	0793	0764	0736	0707	0679	0651	0623	0595	0568	57
58	0851	0822	0793	0764	0735	0707	0678	0650	0622	0595	0567	58
59	0851	0821	0792	0763	0735	0706	0678	0650	0622	0594	0567	59
S.	2° 27′	2° 28′	2° 29′	2° 30′	2° 31′	2° 32′	2° 33′	2° 34′	2° 35′	2° 36′	2° 37′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 2° 38′	h m 2° 39′	h m 2° 40′	h m 2° 41′	h m 2° 42′	h m 2° 43′	h m 2° 44′	h m 2° 45′	h m 2° 46′	h m 2° 47′	h m 2° 48′	S.
0	0566	0539	0512	0484	0458	0431	0404	0378	0352	0326	0300	0
1	0566	0538	0511	0484	0457	0430	0404	0377	0351	0325	0299	1
2	0565	0538	0511	0484	0457	0430	0403	0377	0351	0325	0299	2
3	0565	0537	0510	0483	0456	0430	0403	0377	0350	0324	0298	3
4	0564	0537	0510	0483	0456	0429	0403	0376	0350	0324	0298	4
5	0564	0536	0509	0482	0455	0429	0402	0376	0349	0323	0297	5
6	0563	0536	0509	0482	0455	0428	0402	0375	0349	0323	0297	6
7	0563	0536	0508	0481	0454	0428	0401	0375	0349	0323	0297	7
8	0562	0535	0508	0481	0454	0427	0401	0374	0348	0322	0296	8
9	0562	0535	0507	0480	0454	0427	0400	0374	0348	0322	0296	9
10	0562	0534	0507	0480	0453	0426	0400	0374	0347	0321	0295	10
11	0561	0534	0507	0480	0453	0426	0399	0373	0347	0321	0295	11
12	0561	0533	0506	0479	0452	0426	0399	0373	0346	0320	0294	12
13	0560	0533	0506	0479	0452	0425	0399	0372	0346	0320	0294	13
14	0560	0532	0505	0478	0451	0425	0398	0372	0346	0319	0294	14
15	0559	0532	0505	0478	0451	0424	0398	0371	0345	0319	0293	15
16	0559	0531	0504	0477	0450	0424	0397	0371	0345	0319	0293	16
17	0558	0531	0504	0477	0450	0423	0397	0370	0344	0318	0292	17
18	0558	0531	0503	0476	0450	0423	0396	0370	0344	0318	0292	18
19	0557	0530	0503	0476	0449	0422	0396	0370	0343	0317	0291	19
20	0557	0530	0502	0475	0449	0422	0395	0369	0343	0317	0291	20
21	0557	0529	0502	0475	0448	0422	0395	0369	0342	0316	0291	21
22	0556	0529	0502	0475	0448	0421	0395	0368	0342	0316	0290	22
23	0556	0528	0501	0474	0447	0421	0394	0368	0342	0316	0290	23
24	0555	0528	0501	0474	0447	0420	0394	0367	0341	0315	0289	24
25	0555	0527	0500	0473	0446	0420	0393	0367	0341	0315	0289	25
26	0554	0527	0500	0473	0446	0419	0393	0366	0340	0314	0288	26
27	0554	0526	0499	0472	0446	0419	0392	0366	0340	0314	0288	27
28	0553	0526	0499	0472	0445	0418	0392	0366	0339	0313	0288	28
29	0553	0526	0498	0471	0445	0418	0392	0365	0339	0313	0287	29
30	0552	0525	0498	0471	0444	0418	0391	0365	0339	0313	0287	30
31	0552	0525	0498	0471	0444	0417	0391	0364	0338	0312	0286	31
32	0552	0524	0497	0470	0443	0417	0390	0364	0338	0312	0286	32
33	0551	0524	0497	0470	0443	0416	0390	0363	0337	0311	0285	33
34	0551	0523	0496	0469	0442	0416	0389	0363	0337	0311	0285	34
35	0550	0523	0496	0469	0442	0415	0389	0363	0336	0310	0285	35
36	0550	0522	0495	0468	0442	0415	0388	0362	0336	0310	0284	36
37	0549	0522	0495	0468	0441	0414	0388	0362	0336	0310	0284	37
38	0549	0521	0494	0467	0441	0414	0388	0361	0335	0309	0283	38
39	0548	0521	0494	0467	0440	0414	0387	0361	0335	0309	0283	39
40	0548	0521	0493	0467	0440	0413	0387	0360	0334	0308	0282	40
41	0547	0520	0493	0466	0439	0413	0386	0360	0334	0308	0282	41
42	0547	0520	0493	0466	0439	0412	0386	0359	0333	0307	0282	42
43	0546	0519	0492	0465	0438	0412	0385	0359	0333	0307	0281	43
44	0546	0519	0492	0465	0438	0411	0385	0359	0333	0307	0281	44
45	0546	0518	0491	0464	0438	0411	0384	0358	0332	0306	0280	45
46	0545	0518	0491	0464	0437	0410	0384	0358	0332	0306	0280	46
47	0545	0517	0490	0463	0437	0410	0384	0357	0331	0305	0279	47
48	0544	0517	0490	0463	0436	0410	0383	0357	0331	0305	0279	48
49	0544	0517	0489	0462	0436	0409	0383	0356	0330	0304	0279	49
50	0543	0516	0489	0462	0435	0409	0382	0356	0330	0304	0278	50
51	0543	0516	0489	0462	0435	0408	0382	0356	0329	0304	0278	51
52	0542	0515	0488	0461	0434	0408	0381	0355	0329	0303	0277	52
53	0542	0515	0488	0461	0434	0407	0381	0355	0329	0303	0277	53
54	0541	0514	0487	0460	0434	0407	0381	0354	0328	0302	0276	54
55	0541	0514	0487	0460	0433	0406	0380	0354	0328	0302	0276	55
56	0541	0513	0486	0459	0433	0406	0380	0353	0327	0301	0276	56
57	0540	0513	0486	0459	0432	0406	0379	0353	0327	0301	0275	57
58	0540	0512	0485	0458	0432	0405	0379	0353	0326	0300	0275	58
59	0539	0512	0485	0458	0431	0405	0378	0352	0326	0300	0274	59
S.	2° 38′	2° 39′	2° 40′	2° 41′	2° 42′	2° 43′	2° 44′	2° 45′	2° 46′	2° 47′	2° 48′	S.

Digitized by Google

TABLE XXII.

Proportional Logarithms.

S.	h m 2° 49′	h m 2° 50′	h m 2° 51′	h m 2° 52′	h m 2° 53′	h m 2° 54′	h m 2° 55′	h m 2° 56′	h m 2° 57′	h m 2° 58′	h m 2° 59′	S.
0	0274	0248	0223	0197	0172	0147	0122	0098	0073	0049	0024	0
1	0273	0248	0222	0197	0172	0147	0122	0097	0073	0048	0024	1
2	0273	0247	0222	0197	0171	0146	0122	0097	0072	0048	0023	2
3	0273	0247	0221	0196	0171	0146	0121	0096	0072	0047	0023	3
4	0272	0247	0221	0196	0171	0146	0121	0096	0071	0047	0023	4
5	0272	0246	0221	0195	0170	0145	0120	0096	0071	0046	0022	5
6	0271	0246	0220	0195	0170	0145	0120	0095	0071	0046	0022	6
7	0271	0245	0220	0194	0169	0144	0119	0095	0070	0046	0021	7
8	0270	0245	0219	0194	0169	0144	0119	0094	0070	0045	0021	8
9	0270	0244	0219	0194	0169	0143	0119	0094	0069	0045	0021	9
10	0270	0244	0219	0193	0168	0143	0118	0093	0069	0044	0020	10
11	0269	0244	0218	0193	0168	0143	0118	0093	0068	0044	0020	11
12	0269	0243	0218	0192	0167	0142	0117	0093	0068	0044	0019	12
13	0268	0243	0217	0192	0167	0142	0117	0092	0068	0043	0019	13
14	0268	0242	0217	0192	0166	0141	0117	0092	0067	0043	0019	14
15	0267	0242	0216	0191	0166	0141	0116	0091	0067	0042	0018	15
16	0267	0241	0216	0191	0166	0141	0116	0091	0066	0042	0018	16
17	0267	0241	0216	0190	0165	0140	0115	0091	0066	0042	0017	17
18	0266	0241	0215	0190	0165	0140	0115	0090	0066	0041	0017	18
19	0266	0240	0215	0189	0164	0139	0114	0090	0065	0041	0017	19
20	0265	0240	0214	0189	0164	0139	0114	0089	0065	0040	0016	20
21	0265	0239	0214	0189	0163	0139	0114	0089	0064	0040	0016	21
22	0264	0239	0213	0188	0163	0138	0113	0089	0064	0040	0015	22
23	0264	0238	0213	0188	0163	0138	0113	0088	0064	0039	0015	23
24	0264	0238	0213	0187	0162	0137	0112	0088	0063	0039	0015	24
25	0263	0238	0212	0187	0162	0137	0112	0087	0063	0038	0014	25
26	0263	0237	0212	0187	0161	0136	0112	0087	0062	0038	0014	26
27	0262	0237	0211	0186	0161	0136	0111	0087	0062	0038	0013	27
28	0262	0236	0211	0186	0161	0136	0111	0086	0062	0037	0013	28
29	0261	0236	0211	0185	0160	0135	0110	0086	0061	0037	0012	29
30	0261	0235	0210	0185	0160	0135	0110	0085	0061	0036	0012	30
31	0261	0235	0210	0184	0159	0134	0110	0085	0060	0036	0012	31
32	0260	0235	0209	0184	0159	0134	0109	0084	0060	0036	0011	32
33	0260	0234	0209	0184	0158	0134	0109	0084	0060	0035	0011	33
34	0259	0234	0208	0183	0158	0133	0108	0084	0059	0035	0010	34
35	0259	0233	0208	0183	0158	0133	0108	0083	0059	0034	0010	35
36	0258	0233	0208	0182	0157	0132	0107	0083	0058	0034	0010	36
37	0258	0233	0207	0182	0157	0132	0107	0082	0058	0034	0009	37
38	0258	0232	0207	0181	0156	0131	0107	0082	0057	0033	0009	38
39	0257	0232	0206	0181	0156	0131	0106	0082	0057	0033	0008	39
40	0257	0231	0206	0181	0156	0131	0106	0081	0057	0032	0008	40
41	0256	0231	0205	0180	0155	0130	0105	0081	0056	0032	0008	41
42	0256	0230	0205	0180	0155	0130	0105	0080	0056	0031	0007	42
43	0255	0230	0205	0179	0154	0129	0105	0080	0055	0031	0007	43
44	0255	0230	0204	0179	0154	0129	0104	0080	0055	0031	0006	44
45	0255	0229	0204	0179	0153	0129	0104	0079	0055	0030	0006	45
46	0254	0229	0203	0178	0153	0128	0103	0079	0054	0030	0006	46
47	0254	0228	0203	0178	0153	0128	0103	0078	0054	0029	0005	47
48	0253	0228	0202	0177	0152	0127	0103	0078	0053	0029	0005	48
49	0253	0227	0202	0177	0152	0127	0102	0077	0053	0029	0004	49
50	0252	0227	0202	0176	0151	0126	0102	0077	0053	0028	0004	50
51	0252	0227	0201	0176	0151	0126	0101	0077	0052	0028	0004	51
52	0252	0226	0201	0176	0151	0126	0101	0076	0052	0027	0003	52
53	0251	0226	0200	0175	0150	0125	0100	0076	0051	0027	0003	53
54	0251	0225	0200	0175	0150	0125	0100	0075	0051	0027	0002	54
55	0250	0225	0200	0174	0149	0124	0100	0075	0051	0026	0002	55
56	0250	0224	0199	0174	0149	0124	0099	0075	0050	0026	0002	56
57	0250	0224	0199	0174	0148	0124	0099	0074	0050	0025	0001	57
58	0249	0224	0198	0173	0148	0123	0098	0074	0049	0025	0001	58
59	0249	0223	0198	0173	0148	0123	0098	0073	0049	0025	0000	59
S.	2° 49′	2° 50′	2° 51′	2° 52′	2° 53′	2° 54′	2° 55′	2° 56′	2° 57′	2° 58′	2° 59′	S.

Digitized by Google

TABLE XXIII

To find the Latitude by two Altitudes of the Sun.

HALF ELAPSED TIME.

0 Hour.

M.	0″	10″	20″	30″	40″	50″
0	Infinite.					
0	3.	13833				
0	2.		83730	66121	53627	43936
1	2.36018	29324	23525	18409	13834	09695
2	2.05916	02440				
2	1.		99221	96225	93422	90790
3	1.88307	85959	83732	81613	79593	77663
4	1.75814	74042	72339	70700	69121	67597
5	1.66125	64701	63322	61986	60690	59431
6	1.58208	57018	55861	54733	53634	52561
7	1.51515	50494	49496	48520	47566	46632
8	1.45718	44823	43946	43086	42243	41417
9	1.40605	39809	39027	38258	37503	36762
10	1.36032	35315	34609	33915	33231	32558
11	1.31896	31243	30600	29967	29342	28727
12	1.28120	27522	26931	26349	25774	25207
13	1.24647	24095	23549	23010	22478	21952
14	1.21432	20919	20412	19910	19415	18925
15	1.18440	17961	17487	17018	16554	16096
16	1.15642	15192	14748	14307	13872	13440
17	1.13013	12590	12171	11757	11346	10939
18	1.10536	10136	09740	09348	08960	08574
19	1.08193	07814	07439	07067	06699	06333
20	1.05970	05611	05254	04901	04550	04202
21	1.03857	03515	03175	02838	02504	02172
22	1.01843	01516	01192	00870	00550	00233
23	0.99918	99606	99296	98988	98682	98378
24	0.98077	97777	97480	97184	96891	96600
25	0.96310	96023	95738	95454	95172	94892
26	0.94614	94338	94063	93790	93519	93250
27	0.92982	92716	92452	92189	91928	91669
28	0.91411	91154	90899	90646	90394	90143
29	0.89894	89647	89401	89156	88913	88671
30	0.88430	88191	87953	87717	87481	87247
31	0.87015	86783	86553	86324	86096	85870
32	0.85644	85420	85197	84976	84755	84535
33	0.84317	84100	83884	83669	83455	83242
34	0.83030	82819	82609	82401	82193	81986
35	0.81780	81576	81372	81169	80967	80767
36	0.80567	80368	80170	79973	79777	79581
37	0.79387	79193	79001	78809	78618	78428
38	0.78239	78051	77863	77677	77491	77306
39	0.77122	76938	76756	76574	76393	76212
40	0.76033	75854	75676	75499	75323	75147
41	0.74972	74797	74624	74451	74279	74107
42	0.73937	73767	73597	73429	73261	73093
43	0.72927	72760	72595	72430	72266	72103
44	0.71940	71778	71616	71455	71295	71136
45	0.70976	70818	70660	70503	70346	70190
46	0.70034	69880	69725	69571	69418	69265
47	0.69113	68962	68811	68660	68510	68361
48	0.68212	68064	67916	67769	67622	67476
49	0.67330	67185	67040	66896	66752	66609
50	0.66466	66324	66182	66041	65900	65760
51	0.65620	65481	65342	65204	65066	64928
52	0.64791	64655	64519	64383	64248	64113
53	0.63978	63845	63711	63578	63445	63313
54	0.63181	63050	62919	62789	62659	62529
55	0.62400	62271	62142	62014	61887	61759
56	0.61632	61506	61380	61254	61129	61004
57	0.60879	60755	60631	60508	60385	60262
58	0.60140	60018	59897	59775	59654	59534
59	0.59414	59294	59175	59056	58937	58818

MIDDLE TIME.

0 Hour.

M.	0″	10″	20″	30″	40″	50″
0	Inf.Neg					
0	2.	16270	46373	63982	76476	86167
1	2.94085					
1	3.	00779	06578	11694	16269	20408
2	3.24187	27663	30882	33878	36681	39313
3	3.41796	44144	46371	48490	50510	52440
4	3.54289	56061	57764	59403	60982	62506
5	3.63978	65402	66781	68117	69413	70672
6	3.71895	73085	74242	75370	76469	77542
7	3.78588	79609	80607	81583	82537	83471
8	3.84385	85280	86157	87017	87860	88686
9	3.89498	90294	91076	91845	92600	93341
10	3.94071	94788	95494	96188	96872	97545
11	3.98207	98860	99503			
11	4.			00136	00761	01376
12	4.01983	02581	03172	03754	04329	04896
13	4.05456	06008	06554	07093	07625	08151
14	4.08671	09184	09691	10193	10688	11178
15	4.11663	12142	12616	13085	13549	14007
16	4.14461	14911	15355	15796	16231	16663
17	4.17090	17513	17932	18346	18757	19164
18	4.19567	19967	20363	20755	21143	21529
19	4.21910	22289	22664	23036	23404	23770
20	4.24133	24492	24849	25202	25553	25901
21	4.26246	26588	26928	27265	27599	27931
22	4.28260	28587	28911	29233	29553	29870
23	4.30185	30497	30807	31115	31421	31725
24	4.32026	32326	32623	32919	33212	33503
25	4.33793	34080	34365	34649	34931	35211
26	4.35489	35765	36040	36313	36584	36853
27	4.37121	37387	37651	37914	38175	38434
28	4.38692	38949	39204	39457	39709	39960
29	4.40209	40456	40702	40947	41190	41432
30	4.41673	41912	42150	42386	42622	42856
31	4.43088	43320	43550	43779	44007	44233
32	4.44459	44683	44906	45127	45348	45568
33	4.45786	46003	46219	46434	46648	46861
34	4.47073	47284	47494	47702	47910	48117
35	4.48323	48527	48731	48934	49136	49336
36	4.49536	49735	49933	50130	50326	50522
37	4.50716	50910	51102	51294	51485	51675
38	4.51864	52052	52240	52426	52612	52797
39	4.52981	53165	53347	53529	53710	53891
40	4.54070	54249	54427	54604	54780	54956
41	4.55131	55306	55479	55652	55824	55996
42	4.56166	56336	56506	56674	56842	57010
43	4.57176	57343	57508	57673	57837	58000
44	4.58163	58325	58487	58648	58808	58967
45	4.59127	59285	59443	59600	59757	59913
46	4.60069	60223	60378	60532	60685	60838
47	4.60990	61141	61292	61443	61593	61742
48	4.61891	62039	62187	62334	62481	62627
49	4.62773	62918	63063	63207	63351	63494
50	4.63637	63779	63921	64062	64203	64343
51	4.64483	64622	64761	64899	65037	65175
52	4.65312	65448	65584	65720	65855	65990
53	4.66125	66258	66392	66525	66658	66790
54	4.66922	67053	67184	67314	67444	67574
55	4.67703	67832	67961	68089	68216	68344
56	4.68471	68597	68723	68849	68974	69099
57	4.69224	69348	69472	69595	69718	69841
58	4.69963	70085	70206	70328	70449	70569
59	4.70689	70809	70928	[illegible]	[illegible]	71285

Digitized by Google

TABLE XXIII

To find the Latitude by two Altitudes of the Sun.

HALF ELAPSED TIME.							MIDDLE TIME.						
1 Hour.							1 Hour.						
M.	0″	10″	20″	30″	40″	50″	M.	0″	10″	20″	30″	40″	50″
0	0.58700	58583	58465	58348	58232	58115	0	4.71403	71520	71638	71755	71871	71988
1	0.57999	57884	57768	57653	57539	57424	1	4.72104	72219	72335	72450	72564	72679
2	0.57310	57196	57083	56970	56857	56745	2	4.72793	72907	73020	73133	73246	73358
3	0.56633	56521	56409	56298	56187	56076	3	4.73470	73582	73694	73805	73916	74027
4	0.55966	55856	55747	55637	55528	55419	4	4.74137	74247	74356	74466	74575	74684
5	0.55311	55203	55095	54987	54880	54773	5	4.74792	74900	75008	75116	75223	75330
6	0.54666	54559	54453	54347	54242	54136	6	4.75437	75544	75650	75756	75861	75967
7	0.54031	53926	53822	53718	53614	53510	7	4.76072	76177	76281	76385	76489	76593
8	0.53406	53303	53200	53098	52995	52893	8	4.76697	76800	76903	77005	77108	77210
9	0.52791	52690	52589	52487	52387	52286	9	4.77312	77413	77514	77616	77716	77817
10	0.52186	52086	51986	51886	51787	51688	10	4.77917	78017	78117	78217	78316	78415
11	0.51589	51491	51393	51294	51197	51099	11	4.78514	78612	78710	78809	78906	79004
12	0.51002	50905	50808	50711	50615	50519	12	4.79101	79198	79295	79392	79488	79584
13	0.50423	50327	50232	50137	50042	49947	13	4.79680	79776	79871	79966	80061	80156
14	0.49852	49758	49664	49570	49477	49383	14	4.80251	80345	80439	80533	80626	80720
15	0.49290	49197	49104	49012	48920	48828	15	4.80813	80906	80999	81091	81183	81275
16	0.48736	48644	48553	48462	48371	48280	16	4.81367	81459	81550	81641	81732	81823
17	0.48189	48099	48009	47919	47829	47740	17	4.81914	82004	82094	82184	82274	82363
18	0.47650	47561	47473	47384	47295	47207	18	4.82453	82542	82630	82719	82808	82896
19	0.47119	47031	46944	46856	46769	46682	19	4.82984	83072	83159	83247	83334	83421
20	0.46595	46508	46422	46335	46249	46163	20	4.83508	83595	83681	83768	83854	83940
21	0.46078	45992	45907	45822	45737	45652	21	4.84025	84111	84196	84281	84366	84451
22	0.45567	45483	45399	45315	45231	45147	22	4.84536	84620	84704	84788	84872	84956
23	0.45064	44981	44898	44815	44732	44649	23	4.85039	85122	85205	85288	85371	85454
24	0.44567	44485	44403	44321	44239	44158	24	4.85536	85618	85700	85782	85864	85945
25	0.44077	43995	43915	43834	43753	43673	25	4.86026	86108	86188	86269	86350	86430
26	0.43592	43512	43432	43353	43273	43194	26	4.86511	86591	86671	86750	86830	86909
27	0.43114	43035	42956	42878	42799	42721	27	4.86989	87068	87147	87225	87304	87382
28	0.42642	42564	42486	42409	42331	42254	28	4.87461	87539	87617	87694	87772	87849
29	0.42176	42099	42022	41945	41869	41792	29	4.87927	88004	88081	88158	88234	88311
30	0.41716	41640	41564	41488	41412	41337	30	4.88387	88463	88539	88615	88691	88766
31	0.41261	41186	41111	41036	40961	40887	31	4.88842	88917	88992	89067	89142	89216
32	0.40812	40738	40664	40590	40516	40442	32	4.89291	89365	89439	89513	89587	89661
33	0.40368	40295	40222	40149	40076	40003	33	4.89735	89808	89881	89954	90027	90100
34	0.39930	39857	39785	39713	39641	39569	34	4.90173	90246	90318	90390	90462	90534
35	0.39497	39425	39354	39282	39211	39140	35	4.90606	90678	90749	90821	90892	90963
36	0.39069	38998	38927	38856	38786	38716	36	4.91034	91105	91176	91247	91317	91387
37	0.38646	38575	38506	38436	38366	38297	37	4.91457	91528	91597	91667	91737	91806
38	0.38227	38158	38089	38020	37951	37882	38	4.91876	91945	92014	92083	92152	92221
39	0.37814	37745	37677	37609	37541	37473	39	4.92289	92358	92426	92494	92562	92630
40	0.37405	37338	37270	37203	37135	37068	40	4.92698	92765	92833	92900	92968	93035
41	0.37001	36934	36867	36801	36734	36668	41	4.93102	93169	93236	93302	93369	93435
42	0.36602	36535	36469	36403	36338	36272	42	4.93501	93568	93634	93700	93765	93831
43	0.36206	36141	36076	36011	35946	35881	43	4.93897	93962	94027	94092	94157	94222
44	0.35816	35751	35687	35622	35558	35494	44	4.94287	94352	94416	94481	94545	94609
45	0.35429	35365	35302	35238	35174	35111	45	4.94674	94738	94801	94865	94929	94992
46	0.35047	34984	34921	34858	34795	34732	46	4.95056	95119	95182	95245	95308	95371
47	0.34669	34607	34544	34482	34420	34357	47	4.95434	95496	95559	95621	95683	95746
48	0.34295	34233	34172	34110	34048	33987	48	4.95808	95870	95931	95993	96055	96116
49	0.33925	33864	33803	33742	33681	33620	49	4.96178	96239	96300	96361	96422	96483
50	0.33559	33499	33438	33378	33318	33257	50	4.96544	96604	96665	96725	96785	96846
51	0.33197	33137	33078	33018	32958	32899	51	4.96906	96966	97025	97085	97145	97204
52	0.32839	32780	32720	32661	32602	32543	52	4.97264	97323	97383	97442	97501	97560
53	0.32485	32426	32367	32309	32250	32192	53	4.97618	97677	97736	97794	97853	97911
54	0.32134	32076	32018	31960	31902	31844	54	4.97969	98027	98085	98143	98201	98259
55	0.31787	31729	31672	31614	31557	31500	55	4.98316	98374	98431	98489	98546	98603
56	0.31443	31386	31329	31272	31216	31159	56	4.98660	98717	98774	98831	98887	98944
57	0.31103	31046	30990	30934	30878	30822	57	4.99000	99057	99113	99169	99225	99281
58	0.30766	30710	30655	30599	30544	30488	58	4.99337	99393	99448	99504	99559	99615
59	0.30433	30378	30323	30268	30213	30158	59	4.99670	99725	99780	99835	99890	99945

Digitized by Google

TABLE XXIII.

To find the Latitude by two Altitudes of the Sun.

HALF ELAPSED TIME. 2 Hours.

M.	0″	10″	20″	30″	40″	50″
0	0.30103	30048	29994	29939	29885	29831
1	0.29776	29722	29668	29614	29561	29507
2	0.29453	29400	29346	29293	29239	29186
3	0.29133	29080	29027	28974	28921	28869
4	0.28816	28764	28711	28659	28607	28554
5	0.28502	28450	28398	28346	28295	28243
6	0.28191	28140	28089	28037	27986	27935
7	0.27884	27833	27782	27731	27680	27630
8	0.27579	27529	27478	27428	27378	27327
9	0.27277	27227	27177	27127	27078	27028
10	0.26978	26929	26879	26830	26781	26731
11	0.26682	26633	26584	26535	26487	26438
12	0.26389	26341	26292	26244	26195	26147
13	0.26099	26051	26003	25955	25907	25859
14	0.25811	25763	25716	25668	25621	25573
15	0.25526	25479	25432	25385	25338	25291
16	0.25244	25197	25150	25104	25057	25011
17	0.24964	24918	24872	24825	24779	24733
18	0.24687	24641	24595	24550	24504	24458
19	0.24413	24367	24322	24276	24231	24186
20	0.24141	24096	24051	24006	23961	23916
21	0.23871	23827	23782	23738	23693	23649
22	0.23605	23560	23516	23472	23428	23384
23	0.23340	23296	23253	23209	23165	23122
24	0.23078	23035	22991	22948	22905	22862
25	0.22819	22775	22732	22690	22647	22604
26	0.22561	22519	22476	22433	22391	22349
27	0.22306	22264	22222	22180	22138	22096
28	0.22054	22012	21970	21928	21887	21845
29	0.21803	21762	21720	21679	21638	21596
30	0.21555	21514	21473	21432	21391	21350
31	0.21309	21269	21228	21187	21147	21106
32	0.21066	21025	20985	20945	20905	20864
33	0.20824	20784	20744	20704	20665	20625
34	0.20585	20545	20506	20466	20427	20387
35	0.20348	20309	20269	20230	20191	20152
36	0.20113	20074	20035	19996	19957	19919
37	0.19880	19841	19803	19764	19726	19687
38	0.19649	19611	19572	19534	19496	19458
39	0.19420	19382	19344	19306	19269	19231
40	0.19193	19156	19118	19081	19043	19006
41	0.18968	18931	18894	18857	18820	18783
42	0.18746	18709	18672	18635	18598	18561
43	0.18525	18488	18451	18415	18378	18342
44	0.18306	18269	18233	18197	18161	18125
45	0.18089	18053	18017	17981	17945	17909
46	0.17874	17838	17802	17767	17731	17696
47	0.17660	17625	17590	17554	17519	17484
48	0.17449	17414	17379	17344	17309	17274
49	0.17239	17205	17170	17135	17101	17066
50	0.17032	16997	16963	16928	16894	16860
51	0.16826	16792	16758	16723	16690	16656
52	0.16622	16588	16554	16520	16487	16453
53	0.16419	16386	16352	16319	16285	16252
54	0.16219	16186	16152	16119	16086	16053
55	0.16020	15987	15954	15921	15888	15856
56	0.15823	15790	15758	15725	15692	15660
57	0.15627	15595	15563	15530	15498	15466
58	0.15434	15402	15370	15338	15306	15274
59	0.15242	15210	15178	15146	15115	15083

MIDDLE TIME. 2 Hours.

M.	0″	10″	20″	30″	40″	50″
0	5.00000	00055	00109	00164	00218	00272
1	5.00327	00381	00435	00489	00542	00596
2	5.00650	00703	00757	00810	00864	00917
3	5.00970	01023	01076	01129	01182	01234
4	5.01287	01339	01392	01444	01496	01549
5	5.01601	01653	01705	01757	01808	01860
6	5.01912	01963	02014	02066	02117	02168
7	5.02219	02270	02321	02372	02423	02473
8	5.02524	02574	02625	02675	02725	02776
9	5.02826	02876	02926	02976	03025	03075
10	5.03125	03174	03224	03273	03322	03372
11	5.03421	03470	03519	03568	03616	03665
12	5.03714	03762	03811	03859	03908	03956
13	5.04004	04052	04100	04148	04196	04244
14	5.04292	04340	04387	04435	04482	04530
15	5.04577	04624	04671	04718	04765	04812
16	5.04859	04906	04953	04999	05046	05092
17	5.05139	05185	05231	05278	05324	05370
18	5.05416	05462	05508	05553	05599	05645
19	5.05690	05736	05781	05827	05872	05917
20	5.05962	06007	06052	06097	06142	06187
21	5.06232	06276	06321	06365	06410	06454
22	5.06498	06543	06587	06631	06675	06719
23	5.06763	06807	06850	06894	06938	06981
24	5.07025	07068	07112	07155	07198	07241
25	5.07284	07328	07371	07413	07456	07499
26	5.07542	07584	07627	07670	07712	07754
27	5.07797	07839	07881	07923	07965	08007
28	5.08049	08091	08133	08175	08216	08258
29	5.08300	08341	08383	08424	08465	08507
30	5.08548	08589	08630	08671	08712	08753
31	5.08794	08834	08875	08916	08956	08997
32	5.09037	09078	09118	09158	09198	09239
33	5.09279	09319	09359	09399	09438	09478
34	5.09518	09558	09597	09637	09676	09716
35	5.09755	09794	09834	09873	09912	09951
36	5.09990	10029	10068	10107	10146	10184
37	5.10223	10262	10300	10339	10377	10416
38	5.10454	10492	10531	10569	10607	10645
39	5.10683	10721	10759	10797	10834	10872
40	5.10910	10947	10985	11022	11060	11097
41	5.11135	11172	11209	11246	11283	11320
42	5.11357	11394	11431	11468	11505	11542
43	5.11578	11615	11652	11688	11725	11761
44	5.11797	11834	11870	11906	11942	11978
45	5.12014	12050	12086	12122	12158	12194
46	5.12229	12265	12301	12336	12372	12407
47	5.12443	12478	12513	12549	12584	12619
48	5.12654	12689	12724	12759	12794	12829
49	5.12864	12898	12933	12968	13002	13037
50	5.13071	13106	13140	13175	13209	13243
51	5.13277	13311	13345	13380	13413	13447
52	5.13481	13515	13549	13583	13616	13650
53	5.13684	13717	13751	13784	13818	13851
54	5.13884	13917	13951	13984	14017	14050
55	5.14083	14116	14149	14182	14215	14247
56	5.14280	14313	14345	14378	14411	14443
57	5.14476	14508	14540	14573	14605	14637
58	5.14669	14701	14733	14765	14797	14829
59	5.14861	14893	14925	14957	14988	15020

Digitized by Google

TABLE XXIII.

To find the Latitude by two Altitudes of the Sun

HALF ELAPSED TIME.

3 Hours.

M.	0″	10″	20″	30″	40″	50″
0	0.15051	15020	14988	14957	14926	14894
1	0.14863	14832	14800	14769	14738	14707
2	0.14676	14645	14614	14583	14552	14521
3	0.14490	14460	14429	14398	14368	14337
4	0.14307	14276	14246	14215	14185	14155
5	0.14124	14094	14064	14034	14004	13974
6	0.13944	13914	13884	13854	13824	13794
7	0.13765	13735	13705	13676	13646	13617
8	0.13587	13558	13528	13499	13470	13441
9	0.13411	13382	13353	13324	13295	13266
10	0.13237	13208	13179	13150	13121	13093
11	0.13064	13035	13007	12978	12950	12921
12	0.12893	12864	12836	12808	12779	12751
13	0.12723	12695	12666	12638	12610	12582
14	0.12554	12526	12499	12471	12443	12415
15	0.12387	12360	12332	12305	12277	12249
16	0.12222	12195	12167	12140	12113	12085
17	0.12058	12031	12004	11977	11949	11922
18	0.11895	11868	11842	11815	11788	11761
19	0.11734	11708	11681	11654	11628	11601
20	0.11575	11548	11522	11495	11469	11443
21	0.11416	11390	11364	11338	11312	11285
22	0.11259	11233	11207	11181	11156	11130
23	0.11104	11078	11052	11027	11001	10975
24	0.10950	10924	10899	10873	10848	10822
25	0.10797	10772	10746	10721	10696	10671
26	0.10646	10620	10595	10570	10545	10520
27	0.10496	10471	10446	10421	10396	10371
28	0.10347	10322	10298	10273	10248	10224
29	0.10199	10175	10151	10126	10102	10078
30	0.10053	10029	10005	09981	09957	09933
31	0.09909	09885	09861	09837	09813	09789
32	0.09765	09741	09718	09694	09670	09647
33	0.09623	09599	09576	09552	09529	09506
34	0.09482	09459	09435	09412	09389	09366
35	0.09343	09319	09296	09273	09250	09227
36	0.09204	09181	09158	09136	09113	09090
37	0.09067	09044	09022	08999	08977	08954
38	0.08931	08909	08886	08864	08842	08819
39	0.08797	08775	08752	08730	08708	08686
40	0.08664	08641	08619	08597	08575	08553
41	0.08531	08510	08488	08466	08444	08422
42	0.08401	08379	08357	08336	08314	08293
43	0.08271	08250	08228	08207	08185	08164
44	0.08143	08121	08100	08079	08058	08036
45	0.08015	07994	07973	07952	07931	07910
46	0.07889	07868	07848	07827	07806	07785
47	0.07765	07744	07723	07703	07682	07661
48	0.07641	07620	07600	07579	07559	07539
49	0.07518	07498	07478	07458	07437	07417
50	0.07397	07377	07357	07337	07317	07297
51	0.07277	07257	07237	07217	07197	07178
52	0.07158	07138	07119	07099	07079	07060
53	0.07040	07021	07001	06982	06962	06943
54	0.06923	06904	06885	06866	06846	06827
55	0.06808	06789	06770	06751	06731	06712
56	0.06693	06674	06656	06637	06618	06599
57	0.06580	06561	06543	06524	06505	06487
58	0.06468	06449	06431	06412	06394	06375
59	0.06357	06338	06320	06302	06283	06265

MIDDLE TIME.

3 Hours.

M.	0″	10″	20″	30″	40″	50″
0	5.15051	15083	15115	15146	15177	15209
1	5.15240	15271	15303	15334	15365	15396
2	5.15427	15458	15489	15520	15551	15582
3	5.15613	15643	15674	15705	15735	15766
4	5.15796	15827	15857	15888	15918	15948
5	5.15979	16009	16039	16069	16099	16129
6	5.16159	16189	16219	16249	16279	16309
7	5.16338	16368	16398	16427	16457	16486
8	5.16516	16545	16575	16604	16633	16662
9	5.16692	16721	16750	16779	16808	16837
10	5.16866	16895	16924	16953	16982	17010
11	5.17039	17068	17096	17125	17153	17182
12	5.17210	17239	17267	17295	17324	17352
13	5.17380	17408	17437	17465	17493	17521
14	5.17549	17577	17604	17632	17660	17688
15	5.17716	17743	17771	17798	17826	17854
16	5.17881	17908	17936	17963	17990	18018
17	5.18045	18072	18099	18126	18154	18181
18	5.18208	18235	18261	18288	18315	18342
19	5.18369	18395	18[illegible]2	18449	18475	18502
20	5.18528	18555	18581	18608	18634	18660
21	5.18687	18713	18739	18765	18791	18818
22	5.18844	18870	18896	18922	18947	18973
23	5.18999	19025	19051	19076	19102	19128
24	5.19153	19179	19204	19230	19255	19281
25	5.19306	19331	19357	19382	19407	19432
26	5.19457	19483	19508	19533	19558	19583
27	5.19607	19632	19657	19682	19707	19732
28	5.19756	19781	19805	19830	19855	19879
29	5.19904	19928	19952	19977	20001	20025
30	5.20050	20074	20098	20122	20146	20170
31	5.20194	20218	20242	20266	20290	20314
32	5.20338	20362	20385	20409	20433	20456
33	5.20480	20504	20527	20551	20574	20597
34	5.20621	20644	20668	20691	20714	20737
35	5.20760	20784	20807	20830	20853	20876
36	5.20899	20922	20945	20967	20990	21013
37	5.21036	21059	21081	21104	21126	21149
38	5.21172	21194	21217	21239	21261	21284
39	5.21306	21328	21351	21373	21395	21417
40	5.21439	21462	21484	21506	21528	21550
41	5.21572	21593	21615	21637	21659	21681
42	5.21702	21724	21746	21767	21789	21810
43	5.21832	21853	21875	21896	21918	21939
44	5.21960	21982	22003	22024	22045	22067
45	5.22088	22109	22130	22151	22172	22193
46	5.22214	22235	22255	22276	22297	22318
47	5.22338	22359	22380	22400	22421	22442
48	5.22462	22483	22503	22524	22544	22564
49	5.22585	22605	22625	22645	22666	22686
50	5.22706	22726	22746	22766	22786	22806
51	5.22826	22846	22866	22886	22906	22925
52	5.22945	22965	22984	23004	23024	23043
53	5.23063	23082	23102	23121	23141	23160
54	5.23180	23199	23218	23237	23257	23276
55	5.23295	23314	23333	23352	23372	23391
56	5.23410	23429	23447	23466	23485	23504
57	5.23523	23542	23560	23579	23598	23616
58	5.23635	23654	23672	23691	23709	23728
59	5.23746	23765	23783	23801	23820	23838

Digitized by Google

TABLE XXIII.

To find the Latitude by two Altitudes of the Sun.

HALF ELAPSED TIME. 4 Hours.							MIDDLE TIME. 4 Hours.						
M.	0″	10″	20″	30″	40″	50″	M.	0″	10″	20″	30″	40″	50″
0	0.06247	06229	06211	06192	06174	06156	0	5.23856	23874	23892	23911	23929	23947
1	0.06138	06120	06102	06084	06066	06048	1	5.23965	23983	24001	24019	24037	24055
2	0.06030	06012	05995	05977	05959	05941	2	5.24073	24091	24108	24126	24144	24162
3	0.05924	05906	05888	05871	05853	05836	3	5.24179	24197	24215	24232	24250	24267
4	0.05818	05801	05783	05766	05748	05731	4	5.24285	24302	24320	24337	24355	24372
5	0.05714	05696	05679	05662	05645	05627	5	5.24389	24407	24424	24441	24458	24476
6	0.05610	05593	05576	05559	05542	05525	6	5.24493	24510	24527	24544	24561	24578
7	0.05508	05491	05474	05457	05440	05423	7	5.24595	24612	24629	24646	24663	24680
8	0.05407	05390	05373	05356	05340	05323	8	5.24696	24713	24730	24747	24763	24780
9	0.05306	05290	05273	05257	05240	05224	9	5.24797	24813	24830	24846	24863	24879
10	0.05207	05191	05174	05158	05142	05125	10	5.24896	24912	24929	24945	24961	24978
11	0.05109	05093	05077	05060	05044	05028	11	5.24994	25010	25026	25043	25059	25075
12	0.05012	04996	04980	04964	04948	04932	12	5.25091	25107	25123	25139	25155	25171
13	0.04916	04900	04884	04868	04852	04837	13	5.25187	25203	25219	25235	25251	25266
14	0.04821	04805	04789	04774	04758	04743	14	5.25282	25298	25314	25329	25345	25360
15	0.04727	04711	04696	04680	04665	04649	15	5.25376	25392	25407	25423	25438	25454
16	0.04634	04619	04603	04588	04573	04557	16	5.25469	25484	25500	25515	25530	25546
17	0.04542	04527	04512	04496	04481	04466	17	5.25561	25576	25591	25607	25622	25637
18	0.04451	04436	04421	04406	04391	04376	18	5.25652	25667	25682	25697	25712	25727
19	0.04361	04346	04332	04317	04302	04287	19	5.25742	25757	25771	25786	25801	25816
20	0.04272	04258	04243	04228	04214	04199	20	5.25831	25845	25860	25875	25889	25904
21	0.04185	04170	04156	04141	04127	04112	21	5.25918	25933	25947	25962	25976	25991
22	0.04098	04083	04069	04055	04040	04026	22	5.26005	26020	26034	26048	26063	26077
23	0.04012	03998	03983	03969	03955	03941	23	5.26091	26105	26120	26134	26148	26162
24	0.03927	03913	03899	03885	03871	03857	24	5.26176	26190	26204	26218	26232	26246
25	0.03843	03829	03815	03802	03788	03774	25	5.26260	26274	26288	26301	26315	26329
26	0.03760	03747	03733	03719	03706	03692	26	5.26343	26356	26370	26384	26397	26411
27	0.03678	03665	03651	03638	03624	03611	27	5.26425	26438	26452	26465	26479	26492
28	0.03597	03584	03571	03557	03544	03531	28	5.26506	26519	26532	26546	26559	26572
29	0.03517	03504	03491	03478	03465	03452	29	5.26586	26599	26612	26625	26638	26651
30	0.03438	03425	03412	03399	03386	03373	30	5.26665	26678	26691	26704	26717	26730
31	0.03360	03348	03335	03322	03309	03296	31	5.26743	25755	26768	26781	26794	26807
32	0.03283	03271	03258	03245	03233	03220	32	5.26820	26832	26845	26858	26870	26883
33	0.03207	03195	03182	03170	03157	03145	33	5.26896	26908	26921	26933	26946	26958
34	0.03132	03120	03107	03095	03083	03070	34	5.26971	26983	26996	27008	27020	27033
35	0.03058	03046	03034	03021	03009	02997	35	5.27045	27057	27069	27082	27094	27106
36	0.02985	02973	02961	02949	02937	02925	36	5.27118	27130	27142	27154	27166	27178
37	0.02913	02901	02889	02877	02865	02853	37	5.27190	27[illegible]02	27214	27226	27238	27250
38	0.02841	02829	02818	02806	02794	02783	38	5.27262	27274	27285	27297	27309	27320
39	0.02771	02759	02748	02736	02724	02713	39	5.27332	27344	27355	27367	27379	27390
40	0.02701	02690	02678	02667	02656	02644	40	5.27402	27413	27425	27436	27447	27459
41	0.02633	02622	02610	02599	02588	02577	41	5.27470	27481	27493	27504	27515	27526
42	0.02565	02554	02543	02532	02521	02510	42	5.27538	27549	27560	27571	27582	27593
43	0.02499	02488	02477	02466	02455	02444	43	5.27604	27615	27626	27637	27648	27659
44	0.02433	02422	02411	02400	02390	02379	44	5.27670	27681	27692	27703	27713	27724
45	0.02368	02357	02347	02336	02326	02315	45	5.27735	27746	27756	27767	27777	27788
46	0.02304	02294	02283	02273	02262	02252	46	5.27799	27809	27820	27830	27841	27851
47	0.02241	02231	02221	02210	02200	02190	47	5.27862	27872	27882	27893	27903	27913
48	0.02179	02169	02159	02149	02139	02128	48	5.27924	27934	27944	27954	27964	27975
49	0.02118	02108	02098	02088	02078	02068	49	5.27985	27995	28005	28015	28025	28035
50	0.02058	02048	02038	02028	02018	02009	50	5.28045	28055	28065	28075	28085	28094
51	0.01999	01989	01979	01969	01960	01950	51	5.28104	28114	28124	28134	28143	28153
52	0.01940	01931	01921	01912	01902	01892	52	5.28163	28172	28182	28191	28201	28211
53	0.01883	01873	01864	01854	01845	01836	53	5.28220	28230	28239	28249	28258	28267
54	0.01826	01817	01808	01798	01789	01780	54	5.28277	28286	28295	28305	28314	28323
55	0.01771	01761	01752	01743	01734	01725	55	5.28332	28342	28351	28360	28369	28378
56	0.01716	01707	01698	01689	01680	01671	56	5.28387	28396	28405	28414	28423	28432
57	0.01662	01653	01644	01635	01627	01618	57	5.28441	28450	28459	28468	28476	28485
58	0.01609	01600	01591	01583	01574	01565	58	5.28494	28503	28512	28520	28529	28538
59	0.01557	01548	01540	01531	01523	01514	59	5.28546	28555	28563	28572	28580	28589

Digitized by Google

TABLE XXIII.

To find the Latitude by two Altitudes of the Sun.

HALF ELAPSED TIME.							MIDDLE TIME.						
5 Hours.							5 Hours.						
M.	0″	10″	20″	30″	40″	50″	M.	0″	10″	20″	30″	40″	50″
0	0.01506	01497	01489	01480	01472	01464	0	5.28597	28606	28614	28623	28631	28639
1	0.01455	01447	01439	01430	01422	01414	1	5.28648	28656	28664	28673	28681	28689
2	0.01406	01398	01390	01381	01373	01365	2	5.28697	28705	28713	28722	28730	28738
3	0.01357	01349	01341	01333	01325	01317	3	5.28746	28754	28762	28770	28778	28786
4	0.01310	01302	01294	01286	01278	01271	4	5.28793	28801	28809	28817	28825	28832
5	0.01263	01255	01247	01240	01232	01224	5	5.28840	28848	28856	28863	28871	28879
6	0.01217	01209	01202	01194	01187	01179	6	5.28886	28894	28901	28909	28916	28924
7	0.01172	01164	01157	01150	01142	01135	7	5.28931	28939	28946	28953	28961	28968
8	0.01128	01120	01113	01106	01099	01091	8	5.28975	28983	28990	28997	29004	29012
9	0.01084	01077	01070	01063	01056	01049	9	5.29019	29026	29033	29040	29047	29054
10	0.01042	01035	01028	01021	01014	01007	10	5.29061	29068	29075	29082	29089	29096
11	0.01000	00993	00987	00980	00973	00966	11	5.29103	29110	29116	29123	29130	29137
12	0.00960	00953	00946	00940	00933	00926	12	5.29143	29150	29157	29163	29170	29177
13	0.00920	00913	00907	00900	00894	00887	13	5.29183	29190	29196	29203	29209	29216
14	0.00881	00874	00868	00862	00855	00849	14	5.29222	29229	29235	29241	29248	29254
15	0.00843	00836	00830	00824	00818	00811	15	5.29260	29267	29273	29279	29285	29292
16	0.00805	00799	00793	00787	00781	00775	16	5.29298	29304	29310	29316	29322	29328
17	0.00769	00763	00757	00751	00745	00739	17	5.29334	29340	29346	29352	29358	29364
18	0.00733	00728	00722	00716	00710	00704	18	5.29370	29375	29381	29387	29393	29399
19	0.00699	00693	00687	00682	00676	00670	19	5.29404	29410	29416	29421	29427	29433
20	0.00665	00659	00654	00648	00643	00637	20	5.29438	29444	29449	29455	29460	29466
21	0.00632	00626	00621	00616	00610	00605	21	5.29471	29477	29482	29487	29493	29498
22	0.00600	00594	00589	00584	00579	00574	22	5.29503	29509	29514	29519	29524	29529
23	0.00568	00563	00558	00553	00548	00543	23	5.29535	29540	29545	29550	29555	29560
24	0.00538	00533	00528	00523	00518	00513	24	5.29565	29570	29575	29580	29585	29590
25	0.00508	00504	00499	00494	00489	00484	25	5.29595	29599	29604	29609	29614	29619
26	0.00480	00475	00470	00466	00461	00456	26	5.29623	29628	29633	29637	29642	29647
27	0.00452	00447	00443	00438	00434	00429	27	5.29651	29656	29660	29665	29669	29674
28	0.00425	00420	00416	00412	00407	00403	28	5.29678	29683	29687	29691	29696	29700
29	0.00399	00394	00390	00386	00382	00377	29	5.29704	29709	29713	29717	29721	29726
30	0.00373	00369	00365	00361	00357	00353	30	5.29730	29734	29738	29742	29746	29750
31	0.00349	00345	00341	00337	00333	00329	31	5.29754	29758	29762	29766	29770	29774
32	0.00325	00321	00317	00313	00310	00306	32	5.29778	29782	29786	29790	29793	29797
33	0.00302	00298	00295	00291	00287	00284	33	5.29801	29805	29808	29812	29816	29819
34	0.00280	00276	00273	00269	00266	00262	34	5.29823	29827	29830	29834	29837	29841
35	0.00259	00255	00252	00249	00245	00242	35	5.29844	29848	29851	29854	29858	29861
36	0.00239	00235	00232	00229	00225	00222	36	5.29864	29868	29871	29874	29878	29881
37	0.00219	00216	00213	00210	00207	00203	37	5.29884	29887	29890	29893	29896	29900
38	0.00200	00197	00194	00191	00188	00185	38	5.29903	29906	29909	29912	29915	29918
39	0.00183	00180	00177	00174	00171	00168	39	5.29920	29923	29926	29929	29932	29935
40	0.00166	00163	00160	00157	00155	00152	40	5.29937	29940	29943	29946	29948	29951
*41	0.00149	00147	00144	00142	00139	00137	41	5.29954	29956	29959	29961	29964	29966
42	0.00134	00132	00129	00127	00124	00122	42	5.29969	29971	29974	29976	29979	29981
43	0.00120	00117	00115	00113	00110	00108	43	5.29983	29986	29988	29990	29993	29995
44	0.00106	00104	00102	00099	00097	00095	44	5.29997	29999	30001	30004	30006	30008
45	0.00093	00091	00089	00087	00085	00083	45	5.30010	30012	30014	30016	30018	30020
46	0.00081	00079	00077	00075	00074	00072	46	5.30022	30024	30026	30028	30029	30031
47	0.00070	00068	00066	00065	00063	00061	47	5.30033	30035	30037	30038	30040	30042
48	0.00060	00058	00056	00055	00053	00052	48	5.30043	30045	30047	30048	30050	30051
49	0.00050	00049	00047	00046	00044	00043	49	5.30053	30054	30056	30057	30059	30060
50	0.00041	00040	00039	00037	00036	00035	50	5.30062	30063	30064	30066	30067	30068
51	0.00033	00032	00031	00030	00029	00028	51	5.30070	30071	30072	30073	30074	30075
52	0.00026	00025	00024	00023	00022	00021	52	5.30077	30078	30079	30080	30081	30082
53	0.00020	00019	00018	00017	00017	00016	53	5.30083	30084	30085	30086	30086	30087
54	0.00015	00014	00013	00013	00012	00011	54	5.30088	30089	30090	30090	30091	30092
55	0.00010	00010	00009	00008	00008	00007	55	5.30093	30093	30094	30095	30095	30096
56	0.00007	00006	00006	00005	00005	00004	56	5.30096	30097	30097	30098	30098	30099
57	0.00004	00003	00003	00003	00002	00002	57	5.30099	30100	30100	30100	30101	30101
58	0.00002	00001	00001	00001	00001	00001	58	5.30101	30102	30102	30102	30102	30102
59	0.00000	00000	00000	00000	00000	00000	59	5.30103	30103	30103	30103	30103	30103

Digitized by Google

TABLE XXIII.

To find the Latitude by two Altitudes of the Sun.

LOG. RISING OR VERSED SINE.

0 Hour.

M.	0″	10″	20″	30″	40″	50″
0	Inf.Neg					
	8.	42230				
	9.		02436	37654	62642	82024
1	9.97860					
	0.	11250	22848	33079	42230	50509
2	0.58066	65019	71455	77448	83054	88319
3	0.93284	97980				
	1.		02435	06673	10714	14575
4	1.18271	21817	25224	28502	31660	34708
5	1.37653	40501	43258	45931	48524	51041
6	1.53488	55868	58184	60440	62639	64784
7	1.66877	68920	70917	72869	74778	76646
8	1.78474	80265	82019	83739	85426	87080
9	1.88703	90297	91862	93399	94909	96394
10	1.97854	99289				
	2.		00701	02091	03458	04805
11	2.06131	07437	08723	09991	11240	12472
12	2.13687	14885	16066	17232	18382	19517
13	2.20638	21744	22836	23915	24980	26033
14	2.27073	28100	29116	30120	31112	32093
15	2.33063	34023	34972	35910	36839	37758
16	2.38667	39567	40457	41339	42211	43075
17	2.43930	44777	45616	46447	47270	48685
18	2.48893	49693	50486	51271	52050	52821
19	2.53586	54344	55096	55841	56580	57313
20	2.58039	58759	59474	60182	60885	61582
21	2.62274	62960	63641	64316	64987	65652
22	2.66312	66967	67617	68262	68903	69538
23	2.70170	70796	71418	72036	72649	73258
24	2.73863	74464	75060	75652	76241	76825
25	2.77405	77982	78555	79124	79689	80251
26	2.80809	81363	81914	82461	83005	83546
27	2.84083	84617	85148	85675	86199	86720
28	2.87238	87753	88265	88773	89279	89782
29	2.90282	90779	91273	91765	92254	92739
30	2.93223	93703	94181	94656	95129	95599
31	2.96067	96532	96994	97454	97912	98367
32	2.98820	99270	99719			
	3.			00164	00608	01049
33	3.01488	01925	02360	02792	03222	03651
34	3.04077	04501	04922	05342	05760	06176
35	3.06590	07001	07411	07819	08225	08629
36	3.09032	09432	09831	10227	10622	11015
37	3.11406	11796	12184	12570	12954	13337
38	3.13718	14097	14475	14850	15225	15597
39	3.15969	16338	16706	17072	17437	17800
40	3.18162	18522	18881	19238	19594	19949
41	3.20301	20653	21003	21351	21699	22044
42	3.22389	22732	23073	23414	23753	24090
43	3.24427	24762	25095	25428	25759	26089
44	3.26418	26745	27071	27396	27720	28042
45	3.28363	28683	29002	29320	29637	29952
46	3.30266	30579	30891	31202	31512	31820
47	3.32128	32434	32739	33044	33347	33649
48	3.33950	34250	34549	34847	35144	35439
49	3.35734	36028	36321	36613	36903	37193
50	3.37482	37770	38057	38343	38628	38912
51	3.39195	39477	39759	40039	40319	40597
52	3.40875	41152	41427	41702	41976	42250
53	3.42522	42794	43064	43334	43603	43871
54	3.44138	44405	44670	44935	45199	45462
55	3.45724	45986	46247	46507	46766	47024
56	3.47282	47539	47795	48050	48305	48558
57	3.48811	49064	49315	49566	49816	50066
58	3.50314	50562	50809	51056	51301	51547
59	3.51791	52035	52278	52520	52761	53002

1 Hour.

M.	0′	10″	20″	30″	40″	50″
0	3.53243	53482	53721	53959	54197	54434
1	3.54670	54905	55140	55375	55608	55841
2	3.56074	56306	56537	56767	56997	57226
3	3.57455	57683	57910	58137	58363	58589
4	3.58814	59038	59262	59486	59708	59930
5	3.60152	60373	60593	60813	61032	61251
6	3.61469	61686	61903	62120	62336	62551
7	3.62766	62980	63194	63407	63620	63832
8	3.64043	64254	64465	64675	64885	65094
9	3.65302	65510	65717	65924	66131	66337
10	3.66542	66747	66952	67156	67359	67562
11	3.67765	67967	68168	68369	68570	68770
12	3.68969	69169	69367	69566	69763	69961
13	3.70158	70354	70550	70745	70940	71135
14	3.71329	71523	71716	71909	72101	72293
15	3.72485	72676	72867	73057	73247	73436
16	3.73625	73813	74001	74189	74376	74563
17	3.74750	74936	75121	75307	75491	75676
18	3.75860	76043	76227	76409	76592	76774
19	3.76955	77137	77318	77498	77678	77858
20	3.78037	78216	78395	78573	78750	78928
21	3.79105	79282	79458	79634	79809	79985
22	3.80159	80334	80508	80682	80855	81028
23	3.81201	81373	81545	81717	81888	82059
24	3.82230	82400	82570	82739	82908	83077
25	3.83246	83414	83582	83749	83917	84083
26	3.84250	84416	84582	84748	84913	85078
27	3.85242	85406	85570	85734	85897	86060
28	3.86223	86385	86547	86709	86870	87031
29	3.87192	87352	87513	87672	87832	87991
30	3.88150	88309	88467	88625	88783	88940
31	3.89097	89254	89411	89567	89723	89879
32	3.90034	90189	90344	90498	90653	90807
33	3.90960	91114	91267	91420	91572	91724
34	3.91876	92028	92179	92331	92482	92632
35	3.92782	92933	93082	93232	93381	93530
36	3.93679	93827	93975	94123	94271	94418
37	3.94566	94712	94859	95005	95152	95297
38	3.95443	95588	95733	95878	96023	96167
39	3.96311	96455	96599	96742	96885	97028
40	3.97170	97313	97455	97597	97738	97880
41	3.98021	98162	98302	98443	98583	98723
42	3.98862	99002	99141	99280	99419	99557
43	3.99696	99834	99972			
	4.			00109	00247	00384
44	4.00521	00657	00794	00930	01066	01202
45	4.01337	01473	01608	01743	01877	02012
46	4.02146	02280	02414	02547	02681	02814
47	4.02947	03080	03212	03344	03477	03608
48	4.03740	03871	04003	04134	04265	04395
49	4.04526	04656	04786	04916	05045	05175
50	4.05304	05433	05561	05690	05818	05946
51	4.06074	06202	06330	06457	06584	06711
52	4.06838	06965	07091	07217	07343	07469
53	4.07595	07720	07845	07970	08095	08220
54	4.08344	08468	08592	08716	08840	08964
55	4.09087	09210	09333	09456	09578	09701
56	4.09823	09945	10067	10188	10310	10431
57	4.10552	10673	10794	10915	11035	11155
58	4.11275	11395	11515	11634	11754	11873
59	4.11992	12111	12229	12348	12466	12584

Digitized by Google

TABLE XXIII.

To find the Latitude by two Altitudes of the Sun.

LOG. RISING OR VERSED SINE.

2 Hours.

M.	0″	10″	0″	30″	40″	50′
0	4.12702	12820	12938	13055	13172	13289
1	4.13406	13523	13640	13756	13872	13989
2	4.14104	14220	14336	14451	14567	14682
3	4.14797	14911	15026	15140	15255	15369
4	4.15483	15597	15710	15824	15937	16050
5	4.16163	16276	16389	16501	16614	16726
6	4.16838	16950	17062	17173	17285	17396
7	4.17507	17618	17729	17840	17950	18060
8	4.18171	18281	18391	18500	18610	18719
9	4 18829	18938	19047	19156	19265	19373
10	4.19482	19590	19698	19806	19914	20022
11	4.20129	20236	20344	20451	20558	20665
12	4.20771	20878	20984	21091	21197	21303
13	4.21409	21514	21620	21725	21831	21936
14	4.22041	22146	22250	22355	22459	22564
15	4.22668	22772	22876	22980	23083	23187
16	4.23290	23393	23496	23599	23702	23805
17	4.23907	24010	24112	24214	24316	24418
18	4.24520	24622	24723	24825	24926	25027
19	4.25128	25229	25330	25430	25531	25631
20	4.25731	25831	25931	26031	26131	26231
21	4.26330	26429	26529	26628	26727	26826
22	4.26924	27023	27121	27220	27318	27416
23	4.27514	27612	27710	27807	27905	28002
24	4.28099	28197	28294	28391	28487	28584
25	4.28681	28777	28873	28969	29066	29161
26	4.29257	29353	29449	29544	29639	29735
27	4.29830	29925	30020	30115	30209	30304
28	4.30398	30493	30587	30681	30775	30869
29	4.30963	31056	31150	31243	31337	31430
3c	4.31523	31616	31709	31801	31894	31987
31	4.32079	32171	32264	32356	32448	32540
32	4.32631	32723	32815	32906	32997	33089
33	4.33180	33271	33362	33453	33543	33634
34	4.33724	33815	33905	33995	34085	34175
35	4.34265	34355	34444	34534	34623	34713
36	4.34802	34891	34980	35069	35158	35247
37	4.35335	35424	35512	35601	35689	35777
38	4.35865	35953	36041	36128	36216	36304
39	4.36391	36478	36565	36653	36740	36827
40	4.36913	37000	37087	37173	37260	37346
41	4.37432	37518	37604	37690	37776	37862
42	4.37948	38033	38119	38204	38289	38374
43	4.38460	38545	38629	38714	38799	38884
44	4.38968	39052	39137	39221	39305	39389
45	4.39473	39557	39641	39725	39808	39892
46	4.39975	40058	40142	40225	40308	40391
47	4.40474	40556	40639	40722	40804	40887
48	4.40969	41051	41133	41215	41297	41379
49	4.41461	41543	41624	41706	41787	41868
50	4.41950	42031	42112	42193	42274	42355
51	4.42435	42516	42597	42677	42758	42838
52	4.42918	42998	43078	43158	43238	43318
53	4.43398	43477	43557	43636	43716	43795
54	4.43874	43953	44032	44111	44190	44269
55	4.44348	44426	44505	44583	44662	44740
56	4.44818	44896	44974	45052	45130	45208
57	4.45286	45363	45441	45518	45596	45673
58	4.45750	45827	45905	45982	46058	46135
59	4.46212	46289	46365	46442	46518	46595

3 Hours.

M.	0″	10″	20″	30″	40″	50″
0	4.46671	46747	46823	46899	46975	47051
1	4.47127	47203	47278	47354	47430	47505
2	4.47580	47656	47731	47806	47881	47956
3	4.48031	48106	48180	48255	48330	48404
4	4.48479	48553	48627	48701	48776	48850
5	4.48924	48998	49071	49145	49219	49293
6	4.49366	49440	49513	49586	49660	49733
7	4.49806	49879	49952	50025	50098	50170
8	4.50243	50316	50388	50461	50533	50605
9	4.50677	50750	50822	50894	50966	51038
10	4.51109	51181	51253	51324	51396	51467
11	4.51539	51610	51681	51753	51824	51895
12	4.51966	52037	52107	52178	52249	52319
13	4.52390	52461	52531	52601	52672	52742
14	4.52812	52882	52952	53022	53092	53162
15	4.53231	53301	53371	53440	53510	53579
16	4.53648	53718	53787	53856	53925	53994
17	4.54063	54132	54201	54269	54338	54407
18	4.54475	54544	54612	54680	54749	54817
19	4.54885	54953	55021	55089	55157	55225
20	4.55293	55360	55428	55495	55563	55630
21	4.55698	55765	55832	55900	55967	56034
22	4.56101	56168	56235	56301	56368	56435
23	4.56501	56568	56635	56701	56767	56834
24	4.56900	56966	57032	57098	57164	57230
25	4.57296	57362	57428	57493	57559	57625
26	4.57690	57755	57821	57886	57951	58017
27	4.58082	58147	58212	58277	58342	58407
28	4.58471	58536	58601	58665	58730	58794
29	4.58859	58923	58988	59052	59116	59180
30	4.59244	59308	59372	59436	59500	59564
31	4.59627	59691	59755	59818	59882	59945
32	4.60008	60072	60135	60198	60261	60324
33	4.60388	60450	60513	60576	60639	60701
34	4.60765	60827	60890	60952	61015	61077
35	4.61139	61202	61264	61326	61388	61450
36	4.61512	61574	61636	61698	61760	61822
37	4.61883	61945	62006	62068	62129	62191
38	4.62252	62313	62375	62436	62497	62558
39	4.62619	62680	62741	62802	62863	62923
40	4.62984	63045	63105	63166	63226	63287
41	4.63347	63407	63468	63528	63588	63648
42	4.63708	63768	63828	63888	63948	64008
43	4.64068	64127	64187	64246	64306	64365
44	4.64425	64484	64544	64603	64662	64721
45	4.64780	64839	64898	64957	65016	65075
46	4.65134	65193	65251	65310	65369	65427
47	4.65486	65544	65603	65661	65719	65777
48	4.65836	65894	65952	66010	66068	66126
49	4.66184	66242	66299	66357	66415	66472
50	4.66530	66588	66645	66702	66760	66817
51	4.66875	66932	66989	67046	67103	67160
52	4.67217	67274	67331	67388	67445	67502
53	4.67558	67615	67672	67728	67785	67841
54	4.67897	67954	68010	68066	68123	68179
55	4.68235	68291	68347	68403	68459	68515
56	4.68571	68627	68682	68738	68794	68849
57	4.68905	68960	69016	69071	69127	69182
58	4.69237	69292	69348	69403	69458	69513
59	4.69568	69623	69678	69733	69788	69842

Digitized by Google

TABLE XXIII.

To find the Latitude by two Altitudes of the Sun.

LOG. RISING OR VERSED SINE.

4 Hours.							5 Hours.						
M.	0″	10″	20″	30″	40″	50″	M.	0″	10″	20″	30″	40″	50″
0	4.69897	69952	70006	70061	70115	70170	0	4.86992	87034	87075	87116	87157	87198
1	4.70224	70279	70333	70387	70442	70496	1	4.87239	87280	87321	87362	87402	87443
2	4.70550	70604	70658	70712	70766	70820	2	4.87484	87525	87566	87606	87647	87688
3	4.70874	70928	70982	71036	71089	71143	3	4.87728	87769	87809	87850	87890	87931
4	4.71197	71250	71304	71357	71411	71464	4	4.87971	88012	88052	88093	88133	88173
5	4.71518	71571	71624	71678	71731	71784	5	4.88213	88254	88294	88334	88374	88414
6	4.71837	71890	71943	71996	72049	72102	6	4.88454	88494	88534	88574	88614	88654
7	4.72155	72208	72260	72313	72366	72418	7	4.88694	88734	88774	88814	88853	88893
8	4.72471	72523	72576	72628	72681	72733	8	4.88933	88973	89012	89052	89091	89131
9	4.72785	72838	72890	72942	72994	73046	9	4.89171	89210	89250	89289	89328	89368
10	4.73099	73151	73203	73254	73306	73358	10	4.89407	89447	89486	89525	89564	89604
11	4.73410	73462	73514	73565	73617	73668	11	4.89643	89682	89721	89760	89799	89838
12	4.73720	73772	73823	73874	73926	73977	12	4.89877	89916	89955	89994	90033	90072
13	4.74028	74080	74131	74182	74233	74284	13	4.90111	90150	90188	90227	90266	90305
14	4.74335	74386	74437	74488	74539	74590	14	4.90343	90382	90421	90459	90498	90536
15	4.74641	74692	74742	74793	74844	74894	15	4.90575	90613	90652	90690	90728	90767
16	4.74945	74995	75046	75096	75147	75197	16	4.90805	90843	90882	90920	90958	90996
17	4.75247	75298	75348	75398	75448	75498	17	4.91034	91073	91111	91149	91187	91225
18	4.75549	75599	75649	75699	75748	75798	18	4.91263	91301	91339	91377	91414	91452
19	4.75848	75898	75948	75997	76047	76097	19	4.91490	91528	91566	91603	91641	91679
20	4.76146	76196	76245	76295	76344	76394	20	4.91716	91754	91792	91829	91867	91904
21	4.76443	76492	76542	76591	76640	76689	21	4.91942	91979	92017	92054	92092	92129
22	4.76738	76787	76836	76885	76934	76983	22	4.92166	92203	92241	92278	92315	92352
23	4.77032	77081	77130	77179	77227	77276	23	4.92390	92427	92464	92501	92538	92575
24	4.77325	77373	77422	77470	77519	77567	24	4.92612	92649	92686	92723	92760	92796
25	4.77616	77664	77713	77761	77809	77857	25	4.92833	92870	92907	92944	92980	93017
26	4.77906	77954	78002	78050	78098	78146	26	4.93054	93090	93127	93164	93200	93237
27	4.78194	78242	78290	78338	78385	78433	27	4.93273	93310	93346	93382	93419	93455
28	4.78481	78529	78576	78624	78671	78719	28	4.93492	93528	93564	93600	93637	93673
29	4.78767	78814	78861	78909	78956	79004	29	4.93709	93745	93781	93817	93854	93890
30	4.79051	79098	79145	79192	79240	79287	30	4.93926	93962	93998	94034	94069	94105
31	4.79334	79381	79428	79475	79522	79568	31	4.94141	94177	94213	94249	94284	94320
32	4.79615	79662	79709	79756	79802	79849	32	4.94356	94392	94427	94463	94498	94534
33	4.79896	79942	79989	80035	80082	80128	33	4.94570	94605	94641	94676	94712	94747
34	4.80175	80221	80267	80314	80360	80406	34	4.94782	94818	94853	94888	94924	94959
35	4.80452	80498	80545	80591	80637	80683	35	4.94994	95029	95065	95100	95135	95170
36	4.80729	80775	80820	80866	80912	80958	36	4.95205	95240	95275	95310	95345	95380
37	4.81004	81049	81095	81141	81186	81232	37	4.95415	95450	95485	95520	95555	95589
38	4.81277	81323	81368	81414	81459	81505	38	4.95624	95659	95694	95728	95763	95798
39	4.81550	81595	81641	81686	81731	81776	39	4.95832	95867	95902	95936	95971	96005
40	4.81821	81866	81911	81956	82001	82046	40	4.96040	96074	96109	96143	96177	96212
41	4.82091	82136	82181	82226	82271	82315	41	4.96246	96280	96315	96349	96383	96417
42	4.82360	82405	82449	82494	82538	82583	42	4.96451	96486	96520	96554	96588	96622
43	4.82628	82672	82716	82761	82805	82850	43	4.96656	96690	96724	96758	96792	96826
44	4.82894	82938	82982	83026	83071	83115	44	4.96860	96894	96927	96961	96995	97029
45	4.83159	83203	83247	83291	83335	83379	45	4.97062	97096	97130	97163	97197	97231
46	4.83423	83467	83510	83554	83598	83642	46	4.97264	97298	97331	97365	97398	97432
47	4.83685	83729	83773	83816	83860	83903	47	4.97465	97499	97532	97565	97599	97632
48	4.83947	83990	84034	84077	84120	84164	48	4.97665	97699	97732	97765	97798	97832
49	4.84207	84250	84293	84337	84380	84423	49	4.97865	97898	97931	97964	97997	98030
50	4.84466	84509	84552	84595	84638	84681	50	4.98063	98096	98129	98162	98195	98228
51	4.84724	84767	84810	84852	84895	84938	51	4.98261	98293	98326	98359	98392	98425
52	4.84981	85023	85066	85108	85151	85194	52	4.98457	98490	98523	98555	98588	98620
53	4.85236	85278	85321	85363	85406	85448	53	4.98653	98686	98718	98751	98783	98816
54	4.85490	85533	85575	85617	85659	85701	54	4.98848	98880	98913	98945	98977	99010
55	4.85744	85786	85828	85870	85912	85954	55	4.99042	99074	99107	99139	99171	99203
56	4.85996	86038	86079	86121	86163	86205	56	4.99235	99267	99300	99332	99364	99396
57	4.86247	86288	86330	86372	86413	86455	57	4.99428	99460	99492	99524	99556	99587
58	4.86496	86538	86579	86621	86662	86704	58	4.99619	99651	99683	99715	99747	99778
59	4.86745	86786	86828	86869	86910	86951	59	4.99810	99842	99873	99905	99937	99968

Digitized by Google

TABLE XXIII.

To find the Latitude by two Altitudes of the Sun.

LOG. RISING OR VERSED SINE.

6 Hours.							7 Hours.						
M.	0″	10″	20″	30″	40″	50	M.	0′	10″	20″	30″	40″	50″
0	5.00000	00032	00063	00095	00126	00158	0	5.09996	10021	10045	10069	10093	10117
1	5.00189	00221	00252	00283	00315	00346	1	5.10141	10166	10190	10214	10238	10262
2	5.00377	00409	00440	00471	00502	00534	2	5.10286	10310	10334	10358	10382	10406
3	5.00565	00596	00627	00658	00689	00720	3	5.10430	10454	10477	10501	10525	10549
4	5.00751	00782	00813	00844	00875	00906	4	5.10573	10597	10620	10644	10668	10691
5	5.00937	00968	00999	01030	01061	01091	5	5.10715	10739	10763	10786	10810	10833
6	5.01122	01153	01184	01214	01245	01276	6	5.10857	10881	10904	10928	10951	10975
7	5.01306	01337	01368	01398	01429	01459	7	5.10998	11022	11045	11069	11092	11115
8	5.01490	01520	01551	01581	01612	01642	8	5.11139	11162	11185	11209	11232	11255
9	5.01672	01703	01733	01763	01794	01824	9	5.11279	11302	11325	11348	11372	11395
10	5.01854	01884	01915	01945	01975	02005	10	5.11418	11441	11464	11487	11510	11533
11	5.02035	02065	02095	02125	02155	02185	11	5.11557	11580	11603	11626	11649	11672
12	5.02215	02245	02275	02305	02335	02365	12	5.11695	11717	11740	11763	11786	11809
13	5.02395	02425	02455	02484	02514	02544	13	5.11832	11855	11878	11900	11923	11946
14	5.02574	02603	02633	02663	02692	02722	14	5.11969	11991	12014	12037	12059	12082
15	5.02751	02781	02811	02840	02870	02899	15	5.12105	12127	12150	12173	12195	12218
16	5.02928	02958	02987	03017	03046	03075	16	5.12240	12263	12285	12308	12330	12353
17	5.03105	03134	03163	03193	03222	03251	17	5.12375	12397	12420	12442	12465	12487
18	5.03280	03310	03339	03368	03397	03426	18	5.12509	12532	12554	12576	12598	12621
19	5.03455	03484	03513	03542	03571	03600	19	5.12643	12665	12687	12709	12732	12754
20	5.03629	03658	03687	03716	03745	03774	20	5.12776	12798	12820	12842	12864	12886
21	5.03802	03831	03860	03889	03918	03946	21	5.12908	12930	12952	12974	12996	13018
22	5.03975	04004	04032	04061	04090	04118	22	5.13040	13062	13084	13106	13128	13149
23	5.04147	04175	04204	04232	04261	04289	23	5.13171	13193	13215	13237	13258	13280
24	5.04318	04346	04375	04403	04431	04460	24	5.13302	13323	13345	13367	13388	13410
25	5.04488	04516	04545	04573	04601	04629	25	5.13432	13453	13475	13496	13518	13539
26	5.04657	04686	04714	04742	04770	04798	26	5.13561	13582	13604	13625	13647	13668
27	5.04826	04854	04882	04910	04938	04966	27	5.13690	13711	13732	13754	13775	13797
28	5.04994	05022	05050	05078	05106	05134	28	5.13818	13839	13860	13882	13903	13924
29	5.05162	05189	05217	05245	05273	05300	29	5.13945	13967	13988	14009	14030	14051
30	5.05328	05356	05383	05411	05439	05466	30	5.14072	14093	14114	14136	14157	14178
31	5.05494	05521	05549	05577	05604	05632	31	5.14199	14220	14241	14262	14282	14303
32	5.05659	05686	05714	05741	05769	05796	32	5.14324	14345	14366	14387	14408	14429
33	5.05823	05851	05878	05905	05933	05960	33	5.14449	14470	14491	14512	14533	14553
34	5.05987	06014	06041	06069	06096	06123	34	5.14574	14595	14615	14636	14657	14677
35	5.06150	06177	06204	06231	06258	06285	35	5.14698	14719	14739	14760	14780	14801
36	5.06312	06339	06366	06393	06420	06447	36	5.14821	14842	14862	14883	14903	14924
37	5.06474	06500	06527	06554	06581	06608	37	5.14944	14964	14985	15005	15026	15046
38	5.06634	06661	06688	06714	06741	06768	38	5.15066	15087	15107	15127	15147	15168
39	5.06794	06821	06848	06874	06901	06927	39	5.15188	15208	15228	15248	15269	15289
40	5.06954	06980	07007	07033	07060	07086	40	5.15309	15329	15349	15369	15389	15409
41	5.07112	07139	07165	07192	07218	07244	41	5.15429	15449	15469	15489	15509	15529
42	5.07270	07297	07323	07349	07375	07401	42	5.15549	15569	15589	15609	15629	15649
43	5.07428	07454	07480	07506	07532	07558	43	5.15668	15688	15708	15728	15748	15767
44	5.07584	07610	07636	07662	07688	07714	44	5.15787	15807	15827	15846	15866	15886
45	5.07740	07766	07792	07818	07844	07869	45	5.15905	15925	15944	15964	15984	16003
46	5.07895	07921	07947	07973	07998	08024	46	5.16023	16042	16062	16081	16101	16120
47	5.08050	08075	08101	08127	08152	08178	47	5.16140	16159	16179	16198	16217	16237
48	5.08204	08229	08255	08280	08306	08331	48	5.16256	16276	16295	16314	16333	16353
49	5.08357	08382	08408	08433	08458	08484	49	5.16372	16391	16410	16430	16449	16468
50	5.08509	08534	08560	08585	08610	08636	50	5.16487	16506	16526	16545	16564	16583
51	5.08661	08686	08711	08736	08762	08787	51	5.16602	16621	16640	16659	16678	16697
52	5.08812	08837	08862	08887	08912	08937	52	5.16716	16735	16754	16773	16792	16811
53	5.08962	08987	09012	09037	09062	09087	53	5.16830	16849	16867	16886	16905	16924
54	5.09112	09137	09162	09187	09211	09236	54	5.16943	16961	16980	16999	17018	17036
55	5.09261	09286	09311	09335	09360	09385	55	5.17055	17074	17093	17111	17130	17148
56	5.09409	09434	09459	09483	09508	09533	56	5.17167	17186	17204	17223	17241	17260
57	5.09557	09582	09606	09631	09655	09680	57	5.17278	17297	17315	17334	17352	17371
58	5.09704	09729	09753	09777	09802	09826	58	5.17389	17408	17426	17444	17463	17481
59	5.09851	09875	09899	09924	09948	09972	59	5.17499	17518	17536	17554	17573	17591

Digitized by Google

TABLE XXIII.

To find the Latitude by two Altitudes of the Sun.

LOG. RISING OR VERSED SINE.

8 Hours.							9 Hours.						
M.	0″	10″	20″	30″	40″	50″	M.	0″	10″	20″	30″	40″	50″
0	5.17609	17627	17646	17664	17682	17700	0	5.23226	23239	23252	23265	23278	23291
1	5.17718	17736	17755	17773	17791	17809	1	5.23304	23317	23330	23343	23356	23369
2	5.17827	17845	17863	17881	17899	17917	2	5.23382	23395	23408	23421	23434	23447
3	5.17935	17953	17971	17989	18007	18024	3	5.23459	23472	23485	23498	23511	23523
4	5.18042	18060	18078	18096	18114	18132	4	5.23536	23549	23562	23574	23587	23600
5	5.18149	18167	18185	18203	18220	18238	5	5.23612	23625	23638	23650	23663	23676
6	5.18256	18273	18291	18309	18326	18344	6	5.23688	23701	23714	23726	23739	23751
7	5.18362	18379	18397	18414	18432	18449	7	5.23764	23776	23789	23801	23814	23826
8	5.18467	18484	18502	18519	18537	18554	8	5.23839	23851	23863	23876	23888	23901
9	5.18572	18589	18606	18624	18641	18659	9	5.23913	23925	23938	23950	23962	23975
10	5.18676	18693	18710	18728	18745	18762	10	5.23987	23999	24011	24024	24036	24048
11	5.18780	18797	18814	18831	18848	18866	11	5.24060	24073	24085	24097	24109	24121
12	5.18883	18900	18917	18934	18951	18968	12	5.24133	24145	24158	24170	24182	24194
13	5.18985	19002	19019	19036	19053	19070	13	5.24206	24218	24230	24242	24254	24266
14	5.19087	19104	19121	19138	19155	19172	14	5.24278	24290	24302	24314	24326	24338
15	5.19189	19206	19223	19240	19256	19273	15	5.24349	24361	24373	24385	24397	24409
16	5.19290	19307	19324	19340	19357	19374	16	5.24421	24432	24444	24456	24468	24479
17	5.19390	19407	19424	19441	19457	19474	17	5.24491	24503	24515	24526	24538	24550
18	5.19490	19507	19524	19540	19557	19573	18	5.24561	24573	24585	24596	24608	24619
19	5.19590	19606	19623	19639	19656	19672	19	5.24631	24643	24654	24666	24677	24689
20	5.19689	19705	19722	19738	19754	19771	20	5.24700	24712	24723	24735	24746	24757
21	5.19787	19804	19820	19836	19852	19869	21	5.24769	24780	24792	24803	24814	24826
22	5.19885	19901	19918	19934	19950	19966	22	5.24837	24849	24860	24871	24882	24894
23	5.19982	19999	20015	20031	20047	20063	23	5.24905	24916	24927	24939	24950	24961
24	5.20079	20095	20111	20127	20143	20159	24	5.24972	24983	24995	25006	25017	25028
25	5.20175	20191	20207	20223	20239	20255	25	5.25039	25050	25061	25072	25084	25095
26	5.20271	20287	20303	20319	20335	20351	26	5.25106	25117	25128	25139	25150	25161
27	5.20366	20382	20398	20414	20430	20445	27	5.25172	25182	25193	25204	25215	25226
28	5.20461	20477	20493	20508	20524	20540	28	5.25237	25248	25259	25270	25280	25291
29	5.20555	20571	20587	20602	20618	20634	29	5.25302	25313	25324	25334	25345	25356
30	5.20649	20665	20680	20696	20711	20727	30	5.25367	25377	25388	25399	25409	25420
31	5.20742	20758	20773	20789	20804	20820	31	5.25431	25441	25452	25463	25473	25484
32	5.20835	20850	20866	20881	20897	20912	32	5.25494	25505	25515	25526	25536	25547
33	5 20927	20943	20958	20973	20988	21004	33	5.25557	25568	25578	25589	25599	25610
34	5.21019	21034	21049	21065	21080	21095	34	5.25620	25631	25641	25651	25662	25672
35	5.21110	21125	21140	21155	21170	21186	35	5.25682	25693	25703	25713	25724	25734
36	5.21201	21216	21231	21246	21261	21276	36	5.25744	25755	25765	25775	25785	25795
37	5.21291	21306	21321	21336	21351	21366	37	5.25806	25816	25826	25836	25846	25856
38	5.21380	21395	21410	21425	21440	21455	38	5.25866	25877	25887	25897	25907	25917
39	5.21470	21484	21499	21514	21529	21543	39	5.25927	25937	25947	25957	25967	25977
40	5.21558	21573	21588	21602	21617	21632	40	5.25987	25997	26007	26017	26027	26037
41	5.21646	21661	21676	21690	21705	21719	41	5.26046	26056	26066	26076	26086	26096
42	5.21734	21748	21763	21777	21792	21806	42	5.26105	26115	26125	26135	26145	26154
43	5.21821	21835	21850	21864	21879	21893	43	5.26164	26174	26184	26193	26203	26213
44	5.21908	21922	21936	21951	21965	21979	44	5.26222	26232	26242	26251	26261	26270
45	5.21994	22008	22022	22037	22051	22065	45	5.26280	26290	26299	26309	26318	26328
46	5.22079	22094	22108	22122	22136	22150	46	5.26337	26347	26356	26366	26375	26385
47	5.22164	22179	22193	22207	22221	22235	47	5.26394	26403	26413	26422	26432	26441
48	5.22249	22263	22277	22291	22305	22319	48	5.26450	26460	26469	26478	26488	26497
49	5.22333	22347	22361	22375	22389	22403	49	5.26506	26516	26525	26534	26543	26553
50	5.22417	22431	22445	22458	22472	22486	50	5.26562	26571	26580	26589	26598	26608
51	5.22500	22514	22528	22541	22555	22569	51	5.26617	26626	26635	26644	26653	26662
52	5.22583	22596	22610	22624	22637	22651	52	5.26671	26680	26689	26698	26707	26716
53	5.22665	22678	22692	22706	22719	22733	53	5.26725	26734	26743	26752	26761	26770
54	5.22746	22760	22773	22787	22801	22814	54	5.26779	26788	26797	26806	26815	26823
55	5.22828	22841	22854	22868	22881	22895	55	5.26832	26841	26850	26859	26868	26876
56	5.22908	22922	22935	22948	22962	22975	56	5.26885	26894	26903	26911	26920	26929
57	5.22988	23002	23015	23028	23042	23055	57	5.26937	26946	26955	26963	26972	26981
58	5.23068	23081	23095	23108	23121	23134	58	5.26989	26598	27007	27015	27024	27032
59	5.23147	23160	23174	23187	23200	23213	59	5.27041	27049	27058	27066	27075	27083

Digitized by Google

TABLE XXIII.

To find the Latitude by two Altitudes of the Sun.

LOG. RISING OR VERSED SINE.

10 Hours.							11 Hours.						
M.	0″	10″	20″	30″	40″	50″	M.	0″	10″	20″	30″	40″	50″
0	5.27092	27100	27109	27117	27126	27134	0	5.29357	29361	29365	29369	29373	29377
1	5.27142	27151	27159	27167	27176	27184	1	5.29381	29386	29390	29394	29398	29402
2	5.27192	27201	27209	27217	27226	27234	2	5.29406	29410	29414	29418	29422	29426
3	5.27242	27250	27259	27267	27275	27283	3	5.29430	29434	29438	29441	29445	29449
4	5.27291	27299	27308	27316	27324	27332	4	5.29453	29457	29461	29465	29469	29472
5	5.27340	27348	27356	27364	27372	27380	5	5.29476	29480	29484	29488	29491	29495
6	5.27388	27396	27404	27412	27420	27428	6	5.29499	29503	29506	29510	29514	29517
7	5.27436	27444	27452	27460	27468	27476	7	5.29521	29525	29528	29532	29536	29539
8	5.27484	27492	27500	27507	27515	27523	8	5.29543	29546	29550	29554	29557	29561
9	5.27531	27539	27546	27554	27562	27570	9	5.29564	29568	29571	29575	29578	29582
10	5.27577	27585	27593	27601	27608	27616	10	5.29585	29589	29592	29596	29599	29602
11	5.27624	27631	27639	27647	27654	27662	11	5.29606	29609	29612	29616	29619	29623
12	5.27669	27677	27684	27692	27700	27707	12	5.29626	29629	29632	29636	29639	29642
13	5.27715	27722	27730	27737	27745	27752	13	5.29646	29649	29652	29655	29658	29662
14	5.27759	27767	27774	27782	27789	27796	14	5.29665	29668	29671	29674	29677	29681
15	5.27804	27811	27819	27826	27833	27840	15	5.29684	29687	29690	29693	29696	29699
16	5.27848	27855	27862	27870	27877	27884	16	5.29702	29705	29708	29711	29714	29717
17	5.27891	27899	27906	27913	27920	27927	17	5.29720	29723	29726	29729	29732	29735
18	5.27934	27942	27949	27956	27963	27970	18	5.29738	29741	29744	29747	29749	29752
19	5.27977	27984	27991	27998	28005	28012	19	5.29755	29758	29761	29764	29766	29769
20	5.28019	28026	28033	28040	28047	28054	20	5.29772	29775	29777	29780	29783	29786
21	5.28061	28068	28075	28082	28089	28096	21	5.29788	29791	29794	29796	29799	29802
22	5.28102	28109	28116	28123	28130	28137	22	5.29804	29807	29809	29812	29815	29817
23	5.28143	28150	28157	28164	28170	28177	23	5.29820	29822	29825	29827	29830	29832
24	5.28184	28191	28197	28204	28211	28217	24	5.29835	29837	29840	29842	29845	29847
25	5.28224	28231	28237	28244	28250	28257	25	5.29850	29852	29854	29857	29859	29861
26	5.28264	28270	28277	28283	28290	28296	26	5.29864	29866	29868	29871	29873	29875
27	5.28303	28309	28316	28322	28329	28335	27	5.29878	29880	29882	29884	29887	29889
28	5.28342	28348	28354	28361	28367	28374	28	5.29891	29893	29896	29898	29900	29902
29	5.28380	28386	28393	28399	28405	28411	29	5.29904	29906	29908	29911	29913	29915
30	5.28418	28424	28430	28437	28443	28449	30	5.29917	29919	29921	29923	29925	29927
31	5.28455	28461	28468	28474	28480	28486	31	5.29929	29931	29933	29935	29937	29939
32	5.28492	28498	28505	28511	28517	28523	32	5.29941	29943	29945	29947	29948	29950
33	5.28529	28535	28541	28547	28553	28559	33	5.29952	29954	29956	29958	29960	29961
34	5.28565	28571	28577	28583	28589	28595	34	5.29963	29965	29967	29969	29970	29972
35	5.28601	28607	28613	28619	28624	28630	35	5.29974	29975	29977	29979	29981	29982
36	5.28636	28642	28648	28654	28660	28665	36	5.29984	29986	29987	29989	29990	29992
37	5.28671	28677	28683	28688	28694	28700	37	5.29994	29995	29997	29998	30000	30001
38	5.28706	28711	28717	28723	28728	28734	38	5.30003	30004	30006	30007	30009	30010
39	5.28740	28745	28751	28757	28762	28768	39	5.30012	30013	30015	30016	30018	30019
40	5.28773	28779	28784	28790	28795	28801	40	5.30020	30022	30023	30024	30026	30027
41	5.28806	28812	28817	28823	28828	28834	41	5.30028	30030	30031	30032	30034	30035
42	5.28839	28845	28850	28855	28861	28866	42	5.30036	30037	30038	30040	30041	30042
43	5.28872	28877	28882	28888	28893	28898	43	5.30043	30044	30046	30047	30048	30049
44	5.28904	28909	28914	28919	28925	28930	44	5.30050	30051	30052	30053	30054	30055
45	5.28935	28940	28945	28951	28956	28961	45	5.30056	30058	30059	30060	30061	30062
46	5.28966	28971	28976	28981	28987	28992	46	5.30062	30063	30064	30065	30066	30067
47	5.28997	29002	29007	29012	29017	29022	47	5.30068	30069	30070	30071	30072	30072
48	5.29027	29032	29037	29042	29047	29052	48	5.30073	30074	30075	30076	30076	30077
49	5.29057	29062	29067	29072	29076	29081	49	5.30078	30079	30079	30080	30081	30082
50	5.29086	29091	29096	29101	29106	29110	50	5.30082	30083	30084	30084	30085	30086
51	5.29115	29120	29125	29129	29134	29139	51	5.30086	30087	30087	30088	30089	30089
52	5.29144	29148	29153	29158	29162	29167	52	5.30090	30090	30091	30091	30092	30092
53	5.29172	29176	29181	29186	29190	29195	53	5.30093	30093	30094	30094	30095	30095
54	5.29199	29204	29209	29213	29218	29222	54	5.30096	30096	30096	30097	30097	30097
55	5.29227	29231	29236	29240	29245	29249	55	5.30098	30098	30098	30099	30099	30099
56	5.29254	29258	29262	29267	29271	29276	56	5.30100	30100	30100	30100	30101	30101
57	5.29280	29284	29289	29293	29297	29302	57	5.30101	30101	30102	30102	30102	30102
58	5.29306	29310	29315	29319	29323	29327	58	5.30102	30102	30102	30103	30103	30103
59	5.29332	29336	29340	29344	29348	29353	59	5.30103	30103	30103	30103	30103	30103

Digitized by Google

TABLE XXIV.

Of Natural Sines.

Prop. parts		0°		1°		2°		3°		4°			Prop. parts
29	M	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine	N. cos.	N. sine.	N. cos.		2
0	0	00000	100000	01745	99985	03490	99939	05234	99863	06976	99756	60	2
0	1	00029	100000	01774	99984	03519	99938	05263	99861	07005	99754	59	2
1	2	00058	100000	01803	99984	03548	99937	05292	99860	07034	99752	58	2
1	3	00087	100000	01832	99983	03577	99936	05321	99858	07063	99750	57	2
2	4	00116	100000	01862	99983	03606	99935	05350	99857	07092	99748	56	2
2	5	00145	100000	01891	99982	03635	99934	05379	99855	07121	99746	55	2
3	6	00175	100000	01920	99982	03664	99933	05408	99854	07150	99744	54	2
3	7	00204	100000	01949	99981	03693	99932	05437	99852	07179	99742	53	2
4	8	00233	100000	01978	99980	03723	99931	05466	99851	07208	99740	52	2
4	9	00262	100000	02007	99980	03752	99930	05495	99849	07237	99738	51	2
5	10	00291	100000	02036	99979	03781	99929	05524	99847	07266	99736	50	2
5	11	00320	99999	02065	99979	03810	99927	05553	99846	07295	99734	49	2
6	12	00349	99999	02094	99978	03839	99926	05582	99844	07324	99731	48	2
6	13	00378	99999	02123	99977	03868	99925	05611	99842	07353	99729	47	2
7	14	00407	99999	02152	99977	03897	99924	05640	99841	07382	99727	46	2
7	15	00436	99999	02181	99976	03926	99923	05669	99839	07411	99725	45	2
8	16	00465	99999	02211	99976	03955	99922	05698	99838	07440	99723	44	1
8	17	00495	99999	02240	99975	03984	99921	05727	99836	07469	99721	43	1
9	18	00524	99999	02269	99974	04013	99919	05756	99834	07498	99719	42	1
9	19	00553	99998	02298	99974	04042	99918	05785	99833	07527	99716	41	1
10	20	00582	99998	02327	99973	04071	99917	05814	99831	07556	99714	40	1
10	21	00611	99998	02356	99972	04100	99916	05844	99829	07585	99712	39	1
11	22	00640	99998	02385	99972	04129	99915	05873	99827	07614	99710	38	1
11	23	00669	99998	02414	99971	04159	99913	05902	99826	07643	99708	37	1
12	24	00698	99998	02443	99970	04188	99912	05931	99824	07672	99705	36	1
12	25	00727	99997	02472	99969	04217	99911	05960	99822	07701	99703	35	1
13	26	00756	99997	02501	99969	04246	99910	05989	99821	07730	99701	34	1
13	27	00785	99997	02530	99968	04275	99909	06018	99819	07759	99699	33	1
14	28	00814	99997	02560	99967	04304	99907	06047	99817	07788	99696	32	1
14	29	00844	99996	02589	99966	04333	99906	06076	99815	07817	99694	31	1
15	30	00873	99996	02618	99966	04362	99905	06105	99813	07846	99692	30	1
15	31	00902	99996	02647	99965	04391	99904	06134	99812	07875	99689	29	1
15	32	00931	99996	02676	99964	04420	99902	06163	99810	07904	99687	28	1
16	33	00960	99995	02705	99963	04449	99901	06192	99808	07933	99685	27	1
16	34	00989	99995	02734	99963	04478	99900	06221	99806	07962	99683	26	1
17	35	01018	99995	02763	99962	04507	99898	06250	99804	07991	99680	25	1
17	36	01047	99995	02792	99961	04536	99897	06279	99803	08020	99678	24	1
18	37	01076	99994	02821	99960	04565	99896	06308	99801	08049	99676	23	1
18	38	01105	99994	02850	99959	04594	99894	06337	99799	08078	99673	22	1
19	39	01134	99994	02879	99959	04623	99893	06366	99797	08107	99671	21	1
19	40	01164	99993	02908	99958	04653	99892	06395	99795	08136	99668	20	1
20	41	01193	99993	02938	99957	04682	99890	06424	99793	08165	99666	19	1
20	42	01222	99993	02967	99956	04711	99889	06453	99792	08194	99664	18	1
21	43	01251	99992	02996	99955	04740	99888	06482	99790	08223	99661	17	1
21	44	01280	99992	03025	99954	04769	99886	06511	99788	08252	99659	16	1
22	45	01309	99991	03054	99953	04798	99885	06540	99786	08281	99657	15	1
22	46	01338	99991	03083	99952	04827	99883	06569	99784	08310	99654	14	0
23	47	01367	99991	03112	99952	04856	99882	06598	99782	08339	99652	13	0
23	48	01396	99990	03141	99951	04885	99881	06627	99780	08368	99649	12	0
24	49	01425	99990	03170	99950	04914	99879	06656	99778	08397	99647	11	0
24	50	01454	99989	03199	99949	04943	99878	06685	99776	08426	99644	10	0
25	51	01483	99989	03228	99948	04972	99876	06714	99774	08455	99642	9	0
25	52	01513	99989	03257	99947	05001	99875	06743	99772	08484	99639	8	0
26	53	01542	99988	03286	99946	05030	99873	06773	99770	08513	99637	7	0
26	54	01571	99988	03316	99945	05059	99872	06802	99768	08542	99635	6	0
27	55	01600	99987	03345	99944	05088	99870	06831	99766	08571	99632	5	0
27	56	01629	99987	03374	99943	05117	99869	06860	99764	08600	99630	4	0
28	57	01658	99986	03403	99942	05146	99867	06889	99762	08629	99627	3	0
28	58	01687	99986	03432	99941	05175	99866	06918	99760	08658	99625	2	0
29	59	01716	99985	03461	99940	05205	99864	06947	99758	08687	99622	1	0
29	60	01745	99985	03490	99939	05234	99863	06976	99756	08716	99619	0	0
		N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	M	
		89°		88°		87°		86°		85°			

Digitized by Google

TABLE XXIV.

Of Natural Sines.

Prop. parts		5°		6°		7°		8°		9°			Prop. parts
29	M	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.		4
0	0	08716	99619	10453	99452	12187	99255	13917	99027	15643	98769	60	4
0	1	08745	99617	10482	99449	12216	99251	13946	99023	15672	98764	59	4
1	2	08774	99614	10511	99446	12245	99248	13975	99019	15701	98760	58	4
1	3	08803	99612	10540	99443	12274	99244	14004	99015	15730	98755	57	4
2	4	08831	99609	10569	99440	12302	99240	14033	99011	15758	98751	56	4
2	5	08860	99607	10597	99437	12331	99237	14061	99006	15787	98746	55	4
3	6	08889	99604	10626	99434	12360	99233	14090	99002	15816	98741	54	4
3	7	08918	99602	10655	99431	12389	99230	14119	98998	15845	98737	53	4
4	8	08947	99599	10684	99428	12418	99226	14148	98994	15873	98732	52	3
4	9	08976	99596	10713	99424	12447	99222	14177	98990	15902	98728	51	3
5	10	09005	99594	10742	99421	12476	99219	14205	98986	15931	98723	50	3
5	11	09034	99591	10771	99418	12504	99215	14234	98982	15959	98718	49	3
6	12	09063	99588	10800	99415	12533	99211	14263	98978	15988	98714	48	3
6	13	09092	99586	10829	99412	12562	99208	14292	98973	16017	98709	47	3
7	14	09121	99583	10858	99409	12591	99204	14320	98969	16046	98704	46	3
7	15	09150	99580	10887	99406	12620	99200	14349	98965	16074	98700	45	3
8	16	09179	99578	10916	99402	12649	99197	14378	98961	16103	98695	44	3
8	17	09208	99575	10945	99399	12678	99193	14407	98957	16132	98690	43	3
9	18	09237	99572	10973	99396	12706	99189	14436	98953	16160	98686	42	3
9	19	09266	99570	11002	99393	12735	99186	14464	98948	16189	98681	41	3
10	20	09295	99567	11031	99390	12764	99182	14493	98944	16218	98676	40	3
10	21	09324	99564	11060	99386	12793	99178	14522	98940	16246	98671	39	3
11	22	09353	99562	11089	99383	12822	99175	14551	98936	16275	98667	38	3
11	23	09382	99559	11118	99380	12851	99171	14580	98931	16304	98662	37	2
12	24	09411	99556	11147	99377	12880	99167	14608	98927	16333	98657	36	2
12	25	09440	99553	11176	99374	12908	99163	14637	98923	16361	98652	35	2
13	26	09469	99551	11205	99370	12937	99160	14666	98919	16390	98648	34	2
13	27	09498	99548	11234	99367	12966	99156	14695	98914	16419	98643	33	2
14	28	09527	99545	11263	99364	12995	99152	14723	98910	16447	98638	32	2
14	29	09556	99542	11291	99360	13024	99148	14752	98906	16476	98633	31	2
15	30	09585	99540	11320	99357	13053	99144	14781	98902	16505	98629	30	2
15	31	09614	99537	11349	99354	13081	99141	14810	98897	16533	98624	29	2
15	32	09642	99534	11378	99351	13110	99137	14838	98893	16562	98619	28	2
16	33	09671	99531	11407	99347	13139	99133	14867	98889	16591	98614	27	2
16	34	09700	99528	11436	99344	13168	99129	14896	98884	16620	98609	26	2
17	35	09729	99526	11465	99341	13197	99125	14925	98880	16648	98604	25	2
17	36	09758	99523	11494	99337	13226	99122	14954	98876	16677	98600	24	2
18	37	09787	99520	11523	99334	13254	99118	14982	98871	16706	98595	23	2
18	38	09816	99517	11552	99331	13283	99114	15011	98867	16734	98590	22	1
19	39	09845	99514	11580	99327	13312	99110	15040	98863	16763	98585	21	1
19	40	09874	99511	11609	99324	13341	99106	15069	98858	16792	98580	20	1
20	41	09903	99508	11638	99320	13370	99102	15097	98854	16820	98575	19	1
20	42	09932	99506	11667	99317	13399	99098	15126	98849	16849	98570	18	1
21	43	09961	99503	11696	99314	13427	99094	15155	98845	16878	98565	17	1
21	44	09990	99500	11725	99310	13456	99091	15184	98841	16906	98561	16	1
22	45	10019	99497	11754	99307	13485	99087	15212	98836	16935	98556	15	1
22	46	10048	99494	11783	99303	13514	99083	15241	98832	16964	98551	14	1
23	47	10077	99491	11812	99300	13543	99079	15270	98827	16992	98546	13	1
23	48	10106	99488	11840	99297	13572	99075	15299	98823	17021	98541	12	1
24	49	10135	99485	11869	99293	13600	99071	15327	98818	17050	98536	11	1
24	50	10164	99482	11898	99290	13629	99067	15356	98814	17078	98531	10	1
25	51	10192	99479	11927	99286	13658	99063	15385	98809	17107	98526	9	1
25	52	10221	99476	11956	99283	13687	99059	15414	98805	17136	98521	8	1
26	53	10250	99473	11985	99279	13716	99055	15442	98800	17164	98516	7	0
26	54	10279	99470	12014	99276	13744	99051	15471	98796	17193	98511	6	0
27	55	10308	99467	12043	99272	13773	99047	15500	98791	17222	98506	5	0
27	56	10337	99464	12071	99269	13802	99043	15529	98787	17250	98501	4	0
28	57	10366	99461	12100	99265	13831	99039	15557	98782	17279	98496	3	0
28	58	10395	99458	12129	99262	13860	99035	15586	98778	17308	98491	2	0
29	59	10424	99455	12158	99258	13889	99031	15615	98773	17336	98486	1	0
29	60	10453	99452	12187	99255	13917	99027	15643	98769	17365	98481	0	0
		N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	M	
		84°		83°		82°		81°		80°			

Digitized by Google

TABLE XXIV.

Of Natural Sines.

Prop parts		10°		11°		12°		13°		14°			Prop. parts
28	M	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.		6
0	0	17365	98481	19081	98163	20791	97815	22495	97437	24192	97030	60	6
0	1	17393	98476	19109	98157	20820	97809	22523	97430	24220	97023	59	6
1	2	17422	98471	19138	98152	20848	97803	22552	97424	24249	97015	58	6
1	3	17451	98466	19167	98146	20877	97797	22580	97417	24277	97008	57	6
2	4	17479	98461	19195	98140	20905	97791	22608	97411	24305	97001	56	6
2	5	17508	98455	19224	98135	20933	97784	22637	97404	24333	96994	55	6
3	6	17537	98450	19252	98129	20962	97778	22665	97398	24362	96987	54	5
3	7	17565	98445	19281	98124	20990	97772	22693	97391	24390	96980	53	5
4	8	17594	98440	19309	98118	21019	97766	22722	97384	24418	96973	52	5
4	9	17623	98435	19338	98112	21047	97760	22750	97378	24446	96966	51	5
5	10	17651	98430	19366	98107	21076	97754	22778	97371	24474	96959	50	5
5	11	17680	98425	19395	98101	21104	97748	22807	97365	24503	96952	49	5
6	12	17708	98420	19423	98096	21132	97742	22835	97358	24531	96945	48	5
6	13	17737	98414	19452	98090	21161	97735	22863	97351	24559	96937	47	5
7	14	17766	98409	19481	98084	21189	97729	22892	97345	24587	96930	46	5
7	15	17794	98404	19509	98079	21218	97723	22920	97338	24615	96923	45	5
7	16	17823	98399	19538	98073	21246	97717	22948	97331	24644	96916	44	4
8	17	17852	98394	19566	98067	21275	97711	22977	97325	24672	96909	43	4
8	18	17880	98389	19595	98061	21303	97705	23005	97318	24700	96902	42	4
9	19	17909	98383	19623	98056	21331	97698	23033	97311	24728	96894	41	4
9	20	17937	98378	19652	98050	21360	97692	23062	97304	24756	96887	40	4
10	21	17966	98373	19680	98044	21388	97686	23090	97298	24784	96880	39	4
10	22	17995	98368	19709	98039	21417	97680	23118	97291	24813	96873	38	4
11	23	18023	98362	19737	98033	21445	97673	23146	97284	24841	96866	37	4
11	24	18052	98357	19766	98027	21474	97667	23175	97278	24869	96858	36	4
12	25	18081	98352	19794	98021	21502	97661	23203	97271	24897	96851	35	4
12	26	18109	98347	19823	98016	21530	97655	23231	97264	24925	96844	34	3
13	27	18138	98341	19851	98010	21559	97648	23260	97257	24954	96837	33	3
13	28	18166	98336	19880	98004	21587	97642	23288	97251	24982	96829	32	3
14	29	18195	98331	19908	97998	21616	97636	23316	97244	25010	96822	31	3
14	30	18224	98325	19937	97992	21644	97630	23345	97237	25038	96815	30	3
14	31	18252	98320	19965	97987	21672	97623	23373	97230	25066	96807	29	3
15	32	18281	98315	19994	97981	21701	97617	23401	97223	25094	96800	28	3
15	33	18309	98310	20022	97975	21729	97611	23429	97217	25122	96793	27	3
16	34	18338	98304	20051	97969	21758	97604	23458	97210	25151	96786	26	3
16	35	18367	98299	20079	97963	21786	97598	23486	97203	25179	96778	25	3
17	36	18395	98294	20108	97958	21814	97592	23514	97196	25207	96771	24	2
17	37	18424	98288	20136	97952	21843	97585	23542	97189	25235	96764	23	2
18	38	18452	98283	20165	97946	21871	97579	23571	97182	25263	96756	22	2
18	39	18481	98277	20193	97940	21899	97573	23599	97176	25291	96749	21	2
19	40	18509	98272	20222	97934	21928	97566	23627	97169	25320	96742	20	2
19	41	18538	98267	20250	97928	21956	97560	23656	97162	25348	96734	19	2
20	42	18567	98261	20279	97922	21985	97553	23684	97155	25376	96727	18	2
20	43	18595	98256	20307	97916	22013	97547	23712	97148	25404	96719	17	2
21	44	18624	98250	20336	97910	22041	97541	23740	97141	25432	96712	16	2
21	45	18652	98245	20364	97905	22070	97534	23769	97134	25460	96705	15	2
21	46	18681	98240	20393	97899	22098	97528	23797	97127	25488	96697	14	1
22	47	18710	98234	20421	97893	22126	97521	23825	97120	25516	96690	13	1
22	48	18738	98229	20450	97887	22155	97515	23853	97113	25545	96682	12	1
23	49	18767	98223	20478	97881	22183	97508	23882	97106	25573	96675	11	1
23	50	18795	98218	20507	97875	22212	97502	23910	97100	25601	96667	10	1
24	51	18824	98212	20535	97869	22240	97496	23938	97093	25629	96660	9	1
24	52	18852	98207	20563	97863	22268	97489	23966	97086	25657	96653	8	1
25	53	18881	98201	20592	97857	22297	97483	23995	97079	25685	96645	7	1
25	54	18910	98196	20620	97851	22325	97476	24023	97072	25713	96638	6	1
26	55	18938	98190	20649	97845	22353	97470	24051	97065	25741	96630	5	1
26	56	18967	98185	20677	97839	22382	97463	24079	97058	25769	96623	4	0
27	57	18995	98179	20706	97833	22410	97457	24108	97051	25798	96615	3	0
27	58	19024	98174	20734	97827	22438	97450	24136	97044	25826	96608	2	0
28	59	19052	98168	20763	97821	22467	97444	24164	97037	25854	96600	1	0
28	60	19081	98163	20791	97815	22495	97437	24192	97030	25882	96593	0	0
		N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	M	
		79°		78°		77°		76°		75°			

Digitized by Google

TABLE XXIV.

Of Natural Sines.

Prop. parts	M	15°		16°		17°		18°		19°			Prop. parts
27	M	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.		9
0	0	25882	96593	27564	96126	29237	95630	30902	95106	32557	94552	60	9
0	1	25910	96585	27592	96118	29265	95622	30929	95097	32584	94542	59	9
1	2	25938	96578	27620	96110	29293	95613	30957	95088	32612	94533	58	9
1	3	25966	96570	27648	96102	29321	95605	30985	95079	32639	94523	57	9
2	4	25994	96562	27676	96094	29348	95596	31012	95070	32667	94514	56	8
2	5	26022	96555	27704	96086	29376	95588	31040	95061	32694	94504	55	8
3	6	26050	96547	27731	96078	29404	95579	31068	95052	32722	94495	54	8
3	7	26079	96540	27759	96070	29432	95571	31095	95043	32749	94485	53	8
4	8	26107	96532	27787	96062	29460	95562	31123	95033	32777	94476	52	8
4	9	26135	96524	27815	96054	29487	95554	31151	95024	32804	94466	51	8
5	10	26163	96517	27843	96046	29515	95545	31178	95015	32832	94457	50	8
5	11	26191	96509	27871	96037	29543	95536	31206	95006	32859	94447	49	7
5	12	26219	96502	27899	96029	29571	95528	31233	94997	32887	94438	48	7
6	13	26247	96494	27927	96021	29599	95519	31261	94988	32914	94428	47	7
6	14	26275	96486	27955	96013	29626	95511	31289	94979	32942	94418	46	7
7	15	26303	96479	27983	96005	29654	95502	31316	94970	32969	94409	45	7
7	16	26331	96471	28011	95997	29682	95493	31344	94961	32997	94399	44	7
8	17	26359	96463	28039	95989	29710	95485	31372	94952	33024	94390	43	6
8	18	26387	96456	28067	95981	29737	95476	31399	94943	33051	94380	42	6
9	19	26415	96448	28095	95972	29765	95467	31427	94933	33079	94370	41	6
9	20	26443	96440	28123	95964	29793	95459	31454	94924	33106	94361	40	6
9	21	26471	96433	28150	95956	29821	95450	31482	94915	33134	94351	39	6
10	22	26500	96425	28178	95948	29849	95441	31510	94906	33161	94342	38	6
10	23	26528	96417	28206	95940	29876	95433	31537	94897	33189	94332	37	6
11	24	26556	96410	28234	95931	29904	95424	31565	94888	33216	94322	36	5
11	25	26584	96402	28262	95923	29932	95415	31593	94878	33244	94313	35	5
12	26	26612	96394	28290	95915	29960	95407	31620	94869	33271	94303	34	5
12	27	26640	96386	28318	95907	29987	95398	31648	94860	33298	94293	33	5
13	28	26668	96379	28346	95898	30015	95389	31675	94851	33326	94284	32	5
13	29	26696	96371	28374	95890	30043	95380	31703	94842	33353	94274	31	5
14	30	26724	96363	28402	95882	30071	95372	31730	94832	33381	94264	30	5
14	31	26752	96355	28429	95874	30098	95363	31758	94823	33408	94254	29	4
14	32	26780	96347	28457	95865	30126	95354	31786	94814	33436	94245	28	4
15	33	26808	96340	28485	95857	30154	95345	31813	94805	33463	94235	27	4
15	34	26836	96332	28513	95849	30182	95337	31841	94795	33490	94225	26	4
16	35	26864	96324	28541	95841	30209	95328	31868	94786	33518	94215	25	4
16	36	26892	96316	28569	95832	30237	95319	31896	94777	33545	94206	24	4
17	37	26920	96308	28597	95824	30265	95310	31923	94768	33573	94196	23	3
17	38	26948	96301	28625	95816	30292	95301	31951	94758	33600	94186	22	3
18	39	26976	96293	28652	95807	30320	95293	31979	94749	33627	94176	21	3
18	40	27004	96285	28680	95799	30348	95284	32006	94740	33655	94167	20	3
18	41	27032	96277	28708	95791	30376	95275	32034	94730	33682	94157	19	3
19	42	27060	96269	28736	95782	30403	95266	32061	94721	33710	94147	18	3
19	43	27088	96261	28764	95774	30431	95257	32089	94712	33737	94137	17	3
20	44	27116	96253	28792	95766	30459	95248	32116	94702	33764	94127	16	2
20	45	27144	96246	28820	95757	30486	95240	32144	94693	33792	94118	15	2
21	46	27172	96238	28847	95749	30514	95231	32171	94684	33819	94108	14	2
21	47	27200	96230	28875	95740	30542	95222	32199	94674	33846	94098	13	2
22	48	27228	96222	28903	95732	30570	95213	32227	94665	33874	94088	12	2
22	49	27256	96214	28931	95724	30597	95204	32254	94656	33901	94078	11	2
23	50	27284	96206	28959	95715	30625	95195	32282	94646	33929	94068	10	2
23	51	27312	96198	28987	95707	30653	95186	32309	94637	33956	94058	9	1
23	52	27340	96190	29015	95698	30680	95177	32337	94627	33983	94049	8	1
24	53	27368	96182	29042	95690	30708	95168	32364	94618	34011	94039	7	1
24	54	27396	96174	29070	95681	30736	95159	32392	94609	34038	94029	6	1
25	55	27424	96166	29098	95673	30763	95150	32419	94599	34065	94019	5	1
25	56	27452	96158	29126	95664	30791	95142	32447	94590	34093	94009	4	1
26	57	27480	96150	29154	95656	30819	95133	32474	94580	34120	93999	3	0
26	58	27508	96142	29182	95647	30846	95124	32502	94571	34147	93989	2	0
27	59	27536	96134	29209	95639	30874	95115	32529	94561	34175	93979	1	0
27	60	27564	96126	29237	95630	30902	95106	32557	94552	34202	93969	0	0
		N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	M	
		74°		73°		72°		71°		70°			

Digitized by Google

TABLE XXIV.

Of Natural Sines.

Prop. parts		20°		21°		22°		23°		24°			Prop. parts
27	M	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.		11
0	0	34202	93969	35837	93358	37461	92718	39073	92050	40674	91355	60	11
0	1	34229	93959	35864	93348	37488	92707	39100	92039	40700	91343	59	11
1	2	34257	93949	35891	93337	37515	92697	39127	92028	40727	91331	58	11
1	3	34284	93939	35918	93327	37542	92686	39153	92016	40753	91319	57	10
2	4	34311	93929	35945	93316	37569	92675	39180	92005	40780	91307	56	10
2	5	34339	93919	35973	93306	37595	92664	39207	91994	40806	91295	55	10
3	6	34366	93909	36000	93295	37622	92653	39234	91982	40833	91283	54	10
3	7	34393	93899	36027	93285	37649	92642	39260	91971	40860	91272	53	10
4	8	34421	93889	36054	93274	37676	92631	39287	91959	40886	91260	52	10
4	9	34448	93879	36081	93264	37703	92620	39314	91948	40913	91248	51	9
5	10	34475	93869	36108	93253	37730	92609	39341	91936	40939	91236	50	9
5	11	34503	93859	36135	93243	37757	92598	39367	91925	40966	91224	49	9
5	12	34530	93849	36162	93232	37784	92587	39394	91914	40992	91212	48	9
6	13	34557	93839	36190	93222	37811	92576	39421	91902	41019	91200	47	9
6	14	34584	93829	36217	93211	37838	92565	39448	91891	41045	91188	46	8
7	15	34612	93819	36244	93201	37865	92554	39474	91879	41072	91176	45	8
7	16	34639	93809	36271	93190	37892	92543	39501	91868	41098	91164	44	8
8	17	34666	93799	36298	93180	37919	92532	39528	91856	41125	91152	43	8
8	18	34694	93789	36325	93169	37946	92521	39555	91845	41151	91140	42	8
9	19	34721	93779	36352	93159	37973	92510	39581	91833	41178	91128	41	8
9	20	34748	93769	36379	93148	37999	92499	39608	91822	41204	91116	40	7
9	21	34775	93759	36406	93137	38026	92488	39635	91810	41231	91104	39	7
10	22	34803	93748	36434	93127	38053	92477	39661	91799	41257	91092	38	7
10	23	34830	93738	36461	93116	38080	92466	39688	91787	41284	91080	37	7
11	24	34857	93728	36488	93106	38107	92455	39715	91775	41310	91068	36	7
11	25	34884	93718	36515	93095	38134	92444	39741	91764	41337	91056	35	6
12	26	34912	93708	36542	93084	38161	92432	39768	91752	41363	91044	34	6
12	27	34939	93698	36569	93074	38188	92421	39795	91741	41390	91032	33	6
13	28	34966	93688	36596	93063	38215	92410	39822	91729	41416	91020	32	6
13	29	34993	93677	36623	93052	38241	92399	39848	91718	41443	91008	31	6
14	30	35021	93667	36650	93042	38268	92388	39875	91706	41469	90996	30	6
14	31	35048	93657	36677	93031	38295	92377	39902	91694	41496	90984	29	5
14	32	35075	93647	36704	93020	38322	92366	39928	91683	41522	90972	28	5
15	33	35102	93637	36731	93010	38349	92355	39955	91671	41549	90960	27	5
15	34	35130	93626	36758	92999	38376	92343	39982	91660	41575	90948	26	5
16	35	35157	93616	36785	92988	38403	92332	40008	91648	41602	90936	25	5
16	36	35184	93606	36812	92978	38430	92321	40035	91636	41628	90924	24	4
17	37	35211	93596	36839	92967	38456	92310	40062	91625	41655	90911	23	4
17	38	35239	93585	36867	92956	38483	92299	40088	91613	41681	90899	22	4
18	39	35266	93575	36894	92945	38510	92287	40115	91601	41707	90887	21	4
18	40	35293	93565	36921	92935	38537	92276	40141	91590	41734	90875	20	4
18	41	35320	93555	36948	92924	38564	92265	40168	91578	41760	90863	19	3
19	42	35347	93544	36975	92913	38591	92254	40195	91566	41787	90851	18	3
19	43	35375	93534	37002	92902	38617	92243	40221	91555	41813	90839	17	3
20	44	35402	93524	37029	92892	38644	92231	40248	91543	41840	90826	16	3
20	45	35429	93514	37056	92881	38671	92220	40275	91531	41866	90814	15	3
21	46	35456	93503	37083	92870	38698	92209	40301	91519	41892	90802	14	3
21	47	35484	93493	37110	92859	38725	92198	40328	91508	41919	90790	13	2
22	48	35511	93483	37137	92849	38752	92186	40355	91496	41945	90778	12	2
22	49	35538	93472	37164	92838	38778	92175	40381	91484	41972	90766	11	2
23	50	35565	93462	37191	92827	38805	92164	40408	91472	41998	90753	10	2
23	51	35592	93452	37218	92816	38832	92152	40434	91461	42024	90741	9	2
23	52	35619	93441	37245	92805	38859	92141	40461	91449	42051	90729	8	1
24	53	35647	93431	37272	92794	38886	92130	40488	91437	42077	90717	7	1
24	54	35674	93420	37299	92784	38912	92119	40514	91425	42104	90704	6	1
25	55	35701	93410	37326	92773	38939	92107	40541	91414	42130	90692	5	1
25	56	35728	93400	37353	92762	38966	92096	40567	91402	42156	90680	4	1
26	57	35755	93389	37380	92751	38993	92085	40594	91390	42183	90668	3	1
26	58	35782	93379	37407	92740	39020	92073	40621	91378	42209	90655	2	0
27	59	35810	93368	37434	92729	39046	92062	40647	91366	42235	90643	1	0
27	60	35837	93358	37461	92718	39073	92050	40674	91355	42262	90631	0	0
		N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	M	
		69°		68°		67°		66°		65°			

Digitized by Google

TABLE XXIV.

Of Natural Sines.

Prop. parts		25°		26°		27°		28°		29°			Prop. parts
26	M	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.		14
0	0	42262	90631	43837	89879	45399	89101	46947	88295	48481	87462	60	14
0	1	42288	90618	43863	89867	45425	89087	46973	88281	48506	87448	59	14
1	2	42315	90606	43889	89854	45451	89074	46999	88267	48532	87434	58	14
1	3	42341	90594	43916	89841	45477	89061	47024	88254	48557	87420	57	13
2	4	42367	90582	43942	89828	45503	89048	47050	88240	48583	87406	56	13
2	5	42394	90569	43968	89816	45529	89035	47076	88226	48608	87391	55	13
3	6	42420	90557	43994	89803	45554	89021	47101	88213	48634	87377	54	13
3	7	42446	90545	44020	89790	45580	89008	47127	88199	48659	87363	53	12
3	8	42473	90532	44046	89777	45606	88995	47153	88185	48684	87349	52	12
4	9	42499	90520	44072	89764	45632	88981	47178	88172	48710	87335	51	12
4	10	42525	90507	44098	89752	45658	88968	47204	88158	48735	87321	50	12
5	11	42552	90495	44124	89739	45684	88955	47229	88144	48761	87306	49	11
5	12	42578	90483	44151	89726	45710	88942	47255	88130	48786	87292	48	11
6	13	42604	90470	44177	89713	45736	88928	47281	88117	48811	87278	47	11
6	14	42631	90458	44203	89700	45762	88915	47306	88103	48837	87264	46	11
7	15	42657	90446	44229	89687	45787	88902	47332	88089	48862	87250	45	11
7	16	42683	90433	44255	89674	45813	88888	47358	88075	48888	87235	44	10
7	17	42709	90421	44281	89662	45839	88875	47383	88062	48913	87221	43	10
8	18	42736	90408	44307	89649	45865	88862	47409	88048	48938	87207	42	10
8	19	42762	90396	44333	89636	45891	88848	47434	88034	48964	87193	41	10
9	20	42788	90383	44359	89623	45917	88835	47460	88020	48989	87178	40	9
9	21	42815	90371	44385	89610	45942	88822	47486	88006	49014	87164	39	9
10	22	42841	90358	44411	89597	45968	86808	47511	87993	49040	87150	38	9
10	23	42867	90346	44437	89584	45994	88795	47537	87979	49065	87136	37	9
10	24	42894	90334	44464	89571	46020	88782	47562	87965	49090	87121	36	8
11	25	42920	90321	44490	89558	46046	88768	47588	87951	49116	87107	35	8
11	26	42946	90309	44516	89545	46072	88755	47614	87937	49141	87093	34	8
12	27	42972	90296	44542	89532	46097	88741	47639	87923	49166	87079	33	8
12	28	42999	90284	44568	89519	46123	88728	47665	87909	49192	87064	32	7
13	29	43025	90271	44594	89506	46149	88715	47690	87896	49217	87050	31	7
13	30	43051	90259	44620	89493	46175	88701	47716	87882	49242	87036	30	7
13	31	43077	90246	44646	89480	46201	88688	47741	87868	49268	87021	29	7
14	32	43104	90233	44672	89467	46226	88674	47767	87854	49293	87007	28	7
14	33	43130	90221	44698	89454	46252	88661	47793	87840	49318	86993	27	6
15	34	43156	90208	44724	89441	46278	88647	47818	87826	49344	86978	26	6
15	35	43182	90196	44750	89428	46304	88634	47844	87812	49369	86964	25	6
16	36	43209	90183	44776	89415	46330	88620	47869	87798	49394	86949	24	6
16	37	43235	90171	44802	89402	46355	88607	47895	87784	49419	86935	23	5
16	38	43261	90158	44828	89389	46381	88593	47920	87770	49445	86921	22	5
17	39	43287	90146	44854	89376	46407	88580	47946	87756	49470	86906	21	5
17	40	43313	90133	44880	89363	46433	88566	47971	87743	49495	86892	20	5
18	41	43340	90120	44906	89350	46458	88553	47997	87729	49521	86878	19	4
18	42	43366	90108	44932	89337	46484	88539	48022	87715	49546	86863	18	4
19	43	43392	90095	44958	89324	46510	88526	48048	87701	49571	86849	17	4
19	44	43418	90082	44984	89311	46536	88512	48073	87687	49596	86834	16	4
20	45	43445	90070	45010	89298	46561	88499	48099	87673	49622	86820	15	4
20	46	43471	90057	45036	89285	46587	88485	48124	87659	49647	86805	14	3
20	47	43497	90045	45062	89272	46613	88472	48150	87645	49672	86791	13	3
21	48	43523	90032	45088	89259	46639	88458	48175	87631	49697	86777	12	3
21	49	43549	90019	45114	89245	46664	88445	48201	87617	49723	86762	11	3
22	50	43575	90007	45140	89232	46690	88431	48226	87603	49748	86748	10	2
22	51	43602	89994	45166	89219	46716	88417	48252	87589	49773	86733	9	2
23	52	43628	89981	45192	89206	46742	88404	48277	87575	49798	86719	8	2
23	53	43654	89968	45218	89193	46767	88390	48303	87561	49824	86704	7	2
23	54	43680	89956	45243	89180	46793	88377	48328	87546	49849	86690	6	1
24	55	43706	89943	45269	89167	46819	88363	48354	87532	49874	86675	5	1
24	56	43733	89930	45295	89153	46844	88349	48379	87518	49899	86661	4	1
25	57	43759	89918	45321	89140	46870	88336	48405	87504	49924	86646	3	1
25	58	43785	89905	45347	89127	46896	88322	48430	87490	49950	86632	2	0
26	59	43811	89892	45373	89114	46921	88308	48456	87476	49975	86617	1	0
26	60	43837	89879	45399	89101	46947	88295	48481	87462	50000	86603	0	0
		N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	M	
		64°		63°		62°		61°		60°			

Digitized by Google

TABLE XXIV

Of Natural Sines.

Prop. parts		30°		31°		32°		33°		34°			Prop. parts
25	M	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos		16
0	0	50000	86603	51504	85717	52992	84805	54464	83867	55919	82904	60	16
0	1	50025	86588	51529	85702	53017	84789	54488	83851	55943	82887	59	16
1	2	50050	86573	51554	85687	53041	84774	54513	83835	55968	82871	58	15
1	3	50076	86559	51579	85672	53066	84759	54537	83819	55992	82855	57	15
2	4	50101	86544	51604	85657	53091	84743	54561	83804	56016	82839	56	15
2	5	50126	86530	51628	85642	53115	84728	54586	83788	56040	82822	55	15
3	6	50151	86515	51653	85627	53140	84712	54610	83772	56064	82806	54	14
3	7	50176	86501	51678	85612	53164	84697	54635	83756	56088	82790	53	14
3	8	50201	86486	51703	85597	53189	84681	54659	83740	56112	82773	52	14
4	9	50227	86471	51728	85582	53214	84666	54683	83724	56136	82757	51	14
4	10	50252	86457	51753	85567	53238	84650	54708	83708	56160	82741	50	13
5	11	50277	86442	51778	85551	53263	84635	54732	83692	56184	82724	49	13
5	12	50302	86427	51803	85536	53288	84619	54756	83676	56208	82708	48	13
5	13	50327	86413	51828	85521	53312	84604	54781	83660	56232	82692	47	13
6	14	50352	86398	51852	85506	53337	84588	54805	83645	56256	82675	46	12
6	15	50377	86384	51877	85491	53361	84573	54829	83629	56280	82659	45	12
7	16	50403	86369	51902	85476	53386	84557	54854	83613	56305	82643	44	12
7	17	50428	86354	51927	85461	53411	84542	54878	83597	56329	82626	43	11
8	18	50453	86340	51952	85446	53435	84526	54902	83581	56353	82610	42	11
8	19	50478	86325	51977	85431	53460	84511	54927	83565	56377	82593	41	11
8	20	50503	86310	52002	85416	53484	84495	54951	83549	56401	82577	40	11
9	21	50528	86295	52026	85401	53509	84480	54975	83533	56425	82561	39	10
9	22	50553	86281	52051	85385	53534	84464	54999	83517	56449	82544	38	10
10	23	50578	86266	52076	85370	53558	84448	55024	83501	56473	82528	37	10
10	24	50603	86251	52101	85355	53583	84433	55048	83485	56497	82511	36	10
10	25	50628	86237	52126	85340	53607	84417	55072	83469	56521	82495	35	9
11	26	50654	86222	52151	85325	53632	84402	55097	83453	56545	82478	34	9
11	27	50679	86207	52175	85310	53656	84386	55121	83437	56569	82462	33	9
12	28	50704	86192	52200	85294	53681	84370	55145	83421	56593	82446	32	9
12	29	50729	86178	52225	85279	53705	84355	55169	83405	56617	82429	31	8
13	30	50754	86163	52250	85264	53730	84339	55194	83389	56641	82413	30	8
13	31	50779	86148	52275	85249	53754	84324	55218	83373	56665	82396	29	8
13	32	50804	86133	52299	85234	53779	84308	55242	83356	56689	82380	28	7
14	33	50829	86119	52324	85218	53804	84292	55266	83340	56713	82363	27	7
14	34	50854	86104	52349	85203	53828	84277	55291	83324	56736	82347	26	7
15	35	50879	86089	52374	85188	53858	84261	55315	83308	56760	82330	25	7
15	36	50904	86074	52399	85173	53877	84245	55339	83292	56784	82314	24	6
15	37	50929	86059	52423	85157	53902	84230	55363	83276	56808	82297	23	6
16	38	50954	86045	52448	85142	53926	84214	55388	83260	56832	82281	22	6
16	39	50979	86030	52473	85127	53951	84198	55412	83244	56856	82264	21	6
17	40	51004	86015	52498	85112	53975	84182	55436	83228	56880	82248	20	5
17	41	51029	86000	52522	85096	54000	84167	55460	83212	56904	82231	19	5
18	42	51054	85985	52547	85081	54024	84151	55484	83195	56928	82214	18	5
18	43	51079	85970	52572	85066	54049	84135	55509	83179	56952	82198	17	5
18	44	51104	85956	52597	85051	54073	84120	55533	83163	56976	82181	16	4
19	45	51129	85941	52621	85035	54097	84104	55557	83147	57000	82165	15	4
19	46	51154	85926	52646	85020	54122	84088	55581	83131	57024	82148	14	4
20	47	51179	85911	52671	85005	54146	84072	55605	83115	57047	82132	13	3
20	48	51204	85896	52696	84989	54171	84057	55630	83098	57071	82115	12	3
20	49	51229	85881	52720	84974	54195	84041	55654	83082	57095	82098	11	3
21	50	51254	85866	52745	84959	54220	84025	55678	83066	57119	82082	10	3
21	51	51279	85851	52770	84943	54244	84009	55702	83050	57143	82065	9	2
22	52	51304	85836	52794	84928	54269	83994	55726	83034	57167	82048	8	2
22	53	51329	85821	52819	84913	54293	83978	55750	83017	57191	82032	7	2
23	54	51354	85806	52844	84897	54317	83962	55775	83001	57215	82015	6	2
23	55	51379	85792	52869	84882	54342	83946	55799	82985	57238	81999	5	1
23	56	51404	85777	52893	34866	54366	83930	55823	82969	57262	81982	4	1
24	57	51429	85762	52918	84851	54391	83915	55847	82953	57286	81965	3	1
24	58	51454	85747	52943	84836	54415	83899	55871	82936	57310	81949	2	1
25	59	51479	85732	52967	84820	54440	83883	55895	82920	57334	81932	1	0
25	60	51504	85717	52992	84805	54464	83867	55919	82904	57358	81915	0	0
		N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	M	
		59°		58°		57°		56°		55°			

Digitized by Google

TABLE XXIV.

Of Natural Sines.

Prop. parts		35°		36°		37°		38°		39°			Prop. parts
23	M	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.		18
0	0	57358	81915	58779	80902	60182	79864	61566	78801	62932	77715	60	18
0	1	57381	81899	58802	80885	60205	79846	61589	78783	62955	77696	59	18
1	2	57405	81882	58826	80867	60228	79829	61612	78765	62977	77678	58	17
1	3	57429	81865	58849	80850	60251	79811	61635	78747	63000	77660	57	17
2	4	57453	81848	58873	80833	60274	79793	61658	78729	63022	77641	56	17
2	5	57477	81832	58896	80816	60298	79776	61681	78711	63045	77623	55	17
2	6	57501	81815	58920	80799	60321	79758	61704	78694	63068	77605	54	16
3	7	57524	81798	58943	80782	60344	79741	61726	78676	63090	77586	53	16
3	8	57548	81782	58967	80765	60367	79723	61749	78658	63113	77568	52	16
3	9	57572	81765	58990	80748	60390	79706	61772	78640	63135	77550	51	15
4	10	57596	81748	59014	80730	60414	79688	61795	78622	63158	77531	50	15
4	11	57619	81731	59037	80713	60437	79671	61818	78604	63180	77513	49	15
5	12	57643	81714	59061	80696	60460	79653	61841	78586	63203	77494	48	14
5	13	57667	81698	59084	80679	60483	79635	61864	78568	63225	77476	47	14
5	14	57691	81681	59108	80662	60506	79618	61887	78550	63248	77458	46	14
6	15	57715	81664	59131	80644	60529	79600	61909	78532	63271	77439	45	14
6	16	57738	81647	59154	80627	60553	79583	61932	78514	63293	77421	44	13
7	17	57762	81631	59178	80610	60576	79565	61955	78496	63316	77402	43	13
7	18	57786	81614	59201	80593	60599	79547	61978	78478	63338	77384	42	13
7	19	57810	81597	59225	80576	60622	79530	62001	78460	63361	77366	41	12
8	20	57833	81580	59248	80558	60645	79512	62024	78442	63383	77347	40	12
8	21	57857	81563	59272	80541	60668	79494	62046	78424	63406	77329	39	12
8	22	57881	81546	59295	80524	60691	79477	62069	78405	63428	77310	38	11
9	23	57904	81530	59318	80507	60714	79459	62092	78387	63451	77292	37	11
9	24	57928	81513	59342	80489	60738	79441	62115	78369	63473	77273	36	11
10	25	57952	81496	59365	80472	60761	79424	62138	78351	63496	77255	35	11
10	26	57976	81479	59389	80455	60784	79406	62160	78333	63518	77236	34	10
10	27	57999	81462	59412	80438	60807	79388	62183	78315	63540	77218	33	10
11	28	58023	81445	59436	80420	60830	79371	62206	78297	63563	77199	32	10
11	29	58047	81428	59459	80403	60853	79353	62229	78279	63585	77181	31	9
12	30	58070	81412	59482	80386	60876	79335	62251	78261	63608	77162	30	9
12	31	58094	81395	59506	80368	60899	79318	62274	78243	63630	77144	29	9
12	32	58118	81378	59529	80351	60922	79300	62297	78225	63653	77125	28	8
13	33	58141	81361	59552	80334	60945	79282	62320	78206	63675	77107	27	8
13	34	58165	81344	59576	80316	60968	79264	62342	78188	63698	77088	26	8
13	35	58189	81327	59599	80299	60991	79247	62365	78170	63720	77070	25	8
14	36	58212	81310	59622	80282	61015	79229	62388	78152	63742	77051	24	7
14	37	58236	81293	59646	80264	61038	79211	62411	78134	63765	77033	23	7
15	38	58260	81276	59669	80247	61061	79193	62433	78116	63787	77014	22	7
15	39	58283	81259	59693	80230	61084	79176	62456	78098	63810	76996	21	6
15	40	58307	81242	59716	80212	61107	79158	62479	78079	63832	76977	20	6
16	41	58330	81225	59739	80195	61130	79140	62502	78061	63854	76959	19	6
16	42	58354	81208	59763	80178	61153	79122	62524	78043	63877	76940	18	5
16	43	58378	81191	59786	80160	61176	79105	62547	78025	63899	76921	17	5
17	44	58401	81174	59809	80143	61199	79087	62570	78007	63922	76903	16	5
17	45	58425	81157	59832	80125	61222	79069	62592	77988	63944	76884	15	5
18	46	58449	81140	59856	80108	61245	79051	62615	77970	63966	76866	14	4
18	47	58472	81123	59879	80091	61268	79033	62638	77952	63989	76847	13	4
18	48	58496	81106	59902	80073	61291	79016	62660	77934	64011	76828	12	4
19	49	58519	81089	59926	80056	61314	78998	62683	77916	64033	76810	11	3
19	50	58543	81072	59949	80038	61337	78980	62706	77897	64056	76791	10	3
20	51	58567	81055	59972	80021	61360	78962	62728	77879	64078	76772	9	3
20	52	58590	81038	59995	80003	61383	78944	62751	77861	64100	76754	8	2
20	53	58614	81021	60019	79986	61406	78926	62774	77843	64123	76735	7	2
21	54	58637	81004	60042	79968	61429	78908	62796	77824	64145	76717	6	2
21	55	58661	80987	60065	79951	61451	78891	62819	77806	64167	76698	5	2
21	56	58684	80970	60089	79934	61474	78873	62842	77788	64190	76679	4	1
22	57	58708	80953	60112	79916	61497	78855	62864	77769	64212	76661	3	1
22	58	58731	80936	60135	79899	61520	78837	62887	77751	64234	76642	2	1
23	59	58755	80919	60158	79881	61543	78819	62909	77733	64256	76623	1	0
23	60	58779	80902	60182	79864	61566	78801	62932	77715	64279	76604	0	0
		N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	M	
		54°		53°		52°		51°		50°			

Digitized by Google

TABLE XXIV.

Of Natural Sines.

Prop. parts 22	M	40° N. sine.	40° N. cos.	41° N. sine.	41° N. cos.	42° N. sine.	42° N. cos.	43° N. sine.	43° N. cos.	44° N. sine.	44° N. cos.		Prop. parts 19
0	0	64279	76604	65606	75471	66913	74314	68200	73135	69466	71934	60	19
0	1	64301	76586	65628	75452	66935	74295	68221	73116	69487	71914	59	19
1	2	64323	76567	65650	75433	66956	74276	68242	73096	69508	71894	58	18
1	3	64346	76548	65672	75414	66978	74256	68264	73076	69529	71873	57	18
1	4	64368	76530	65694	75395	66999	74237	68285	73056	69549	71853	56	18
2	5	64390	76511	65716	75375	67021	74217	68306	73036	69570	71833	55	17
2	6	64412	76492	65738	75356	67043	74198	68327	73016	69591	71813	54	17
3	7	64435	76473	65759	75337	67064	74178	68349	72996	69612	71792	53	17
3	8	64457	76455	65781	75318	67086	74159	68370	72976	69633	71772	52	16
3	9	64479	76436	65803	75299	67107	74139	68391	72957	69654	71752	51	16
4	10	64501	76417	65825	75280	67129	74120	68412	72937	69675	71732	50	16
4	11	64524	76398	65847	75261	67151	74100	68434	72917	69696	71711	49	16
4	12	64546	76380	65869	75241	67172	74080	68455	72897	69717	71691	48	15
5	13	64568	76361	65891	75222	67194	74061	68476	72877	69737	71671	47	15
5	14	64590	76342	65913	75203	67215	74041	68497	72857	69758	71650	46	15
6	15	64612	76323	65935	75184	67237	74022	68518	72837	69779	71630	45	14
6	16	64635	76304	65956	75165	67258	74002	68539	72817	69800	71610	44	14
6	17	64657	76286	65978	75146	67280	73983	68561	72797	69821	71590	43	14
7	18	64679	76267	66000	75126	67301	73963	68582	72777	69842	71569	42	13
7	19	64701	76248	66022	75107	67323	73944	68603	72757	69862	71549	41	13
7	20	64723	76229	66044	75088	67344	73924	68624	72737	69883	71529	40	13
8	21	64746	76210	66066	75069	67366	73904	68645	72717	69904	71508	39	12
8	22	64768	76192	66088	75050	67387	73885	68666	72697	69925	71488	38	12
8	23	64790	76173	66109	75030	67409	73865	68688	72677	69946	71468	37	12
9	24	64812	76154	66131	75011	67430	73846	68709	72657	69966	71447	36	11
9	25	64834	76135	66153	74992	67452	73826	68730	72637	69987	71427	35	11
10	26	64856	76116	66175	74973	67473	73806	68751	72617	70008	71407	34	11
10	27	64878	76097	66197	74953	67495	73787	68772	72597	70029	71386	33	10
10	28	64901	76078	66218	74934	67516	73767	68793	72577	70049	71366	32	10
11	29	64923	76059	66240	74915	67538	73747	68814	72557	70070	71345	31	10
11	30	64945	76041	66262	74896	67559	73728	68835	72537	70091	71325	30	10
11	31	64967	76022	66284	74876	67580	73708	68857	72517	70112	71305	29	9
12	32	64989	76003	66306	74857	67602	73688	68878	72497	70132	71284	28	9
12	33	65011	75984	66327	74838	67623	73669	68899	72477	70153	71264	27	9
12	34	65033	75965	66349	74818	67645	73649	68920	72457	70174	71243	26	8
13	35	65055	75946	66371	74799	67666	73629	68941	72437	70195	71223	25	8
13	36	65077	75927	66393	74780	67688	73610	68962	72417	70215	71203	24	8
14	37	65100	75908	66414	74760	67709	73590	68983	72397	70236	71182	23	7
14	38	65122	75889	66436	74741	67730	73570	69004	72377	70257	71162	22	7
14	39	65144	75870	66458	74722	67752	73551	69025	72357	70277	71141	21	7
15	40	65166	75851	66480	74703	67773	73531	69046	72337	70298	71121	20	6
15	41	65188	75832	66501	74683	67795	73511	69067	72317	70319	71100	19	6
15	42	65210	75813	66523	74664	67816	73491	69088	72297	70339	71080	18	6
16	43	65232	75794	66545	74644	67837	73472	69109	72277	70360	71059	17	5
16	44	65254	75775	66566	74625	67859	73452	69130	72257	70381	71039	16	5
17	45	65276	75756	66588	74606	67880	73432	69151	72236	70401	71019	15	5
17	46	65298	75738	66610	74586	67901	73413	69172	72216	70422	70998	14	4
17	47	65320	75719	66632	74567	67923	73393	69193	72196	70443	70978	13	4
18	48	65342	75700	66653	74548	67944	73373	69214	72176	70463	70957	12	4
18	49	65364	75680	66675	74528	67965	73353	69235	72156	70484	70937	11	3
18	50	65386	75661	66697	74509	67987	73333	69256	72136	70505	70916	10	3
19	51	65408	75642	66718	74489	68008	73314	69277	72116	70525	70896	9	3
19	52	65430	75623	66740	74470	68029	73294	69298	72095	70546	70875	8	3
19	53	65452	75604	66762	74451	68051	73274	69319	72075	70567	70855	7	2
20	54	65474	75585	66783	74431	68072	73254	69340	72055	70587	70834	6	2
20	55	65496	75566	66805	74412	68093	73234	69361	72035	70608	70813	5	2
21	56	65518	75547	66827	74392	68115	73215	69382	72015	70628	70793	4	1
21	57	65540	75528	66848	74373	68136	73195	69403	71995	70649	70772	3	1
21	58	65562	75509	66870	74353	68157	73175	69424	71974	70670	70752	2	1
22	59	65584	75490	66891	74334	68179	73155	69445	71954	70690	70731	1	0
22	60	65606	75471	66913	74314	68200	73135	69466	71934	70711	70711	0	0
		N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	M	
		49°		48°		47°		46°		45°			

Digitized by Google

TABLE XXV

Of Logarithmic Sines, Tangents, and Secants to every Point and Quarter Point of the Compass.

Points.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant.	
0	Inf. neg.	10.00000	Inf. neg.	Infinite.	10.00000	Infinite.	8
0 ¼	8.69080	9.99948	8.69132	11.30868	10.00052	11.30920	7 ¾
0 ½	8.99130	9.99790	8.99340	11.00660	10.00210	11.00870	7 ½
0 ¾	9.16652	9.99527	9.17125	10.82875	10.00473	10.83348	7 ¼
1	9.29024	9.99157	9.29866	10.70134	10.00843	10.70976	7
1 ¼	9.38557	9.98679	9.39879	10.60121	10.01321	10.61443	6 ¾
1 ½	9.46282	9.98088	9.48194	10.51806	10.01912	10.53718	6 ½
1 ¾	9.52749	9.97384	9.55365	10.44635	10.02616	10.47251	6 ¼
2	9.58284	9.96562	9.61722	10.38278	10.03438	10.41716	6
2 ¼	9.63099	9.95616	9.67483	10.32517	10.04384	10.36901	5 ¾
2 ½	9.67339	9.94543	9.72796	10.27204	10.05457	10.32661	5 ½
2 ¾	9.71105	9.93335	9.77770	10.22230	10.06665	10.28895	5 ¼
3	9.74474	9.91985	9.82489	10.17511	10.08015	10.25526	5
3 ¼	9.77503	9.90483	9.87020	10.12980	10.09517	10.22497	4 ¾
3 ½	9.80236	9.88819	9.91417	10.08583	10.11181	10.19764	4 ½
3 ¾	9.82708	9.86979	9.95729	10.04271	10.13021	10.17292	4 ¼
4	9.84949	9.84949	10.00000	10.00000	10.15051	10.15051	4
	Co-sine.	Sine.	Co-tang.	Tangent.	Co secant.	Secant.	Points.

TABLE XXVI.

Logarithms of Numbers.

No. 1——100. Log. 0.00000——2.00000.

No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0.00000	21	1.32222	41	1.61278	61	1.78533	81	1.90849
2	0.30103	22	1.34242	42	1.62325	62	1.79239	82	1.91381
3	0.47712	23	1.36173	43	1.63347	63	1.79934	83	1.91908
4	0.60206	24	1.38021	44	1.64345	64	1.80618	84	1.92428
5	0.69897	25	1.39794	45	1.65321	65	1.81291	85	1.92942
6	0.77815	26	1.41497	46	1.66276	66	1.81954	86	1.93450
7	0.84510	27	1.43136	47	1.67210	67	1.82607	87	1.93952
8	0.90309	28	1.44716	48	1.68124	68	1.83251	88	1.94448
9	0.95424	29	1.46240	49	1.69020	69	1.83885	89	1.94939
10	1.00000	30	1.47712	50	1.69897	70	1.84510	90	1.95424
11	1.04139	31	1.49136	51	1.70757	71	1.85126	91	1.95904
12	1.07918	32	1.50515	52	1.71600	72	1.85733	92	1.96379
13	1.11394	33	1.51851	53	1.72428	73	1.86332	93	1.96848
14	1.14613	34	1.53148	54	1.73239	74	1.86923	94	1.97313
15	1.17609	35	1.54407	55	1.74036	75	1.87506	95	1.97772
16	1.20412	36	1.55630	56	1.74819	76	1.88081	96	1.98227
17	1.23045	37	1.56820	57	1.75587	77	1.88649	97	1.98677
18	1.25527	38	1.57978	58	1.76343	78	1.89209	98	1.99123
19	1.27875	39	1.59106	59	1.77085	79	1.89763	99	1.99564
20	1.30103	40	1.60206	60	1.77815	80	1.90309	100	2.00000

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 100——1600. **Log. 00000——20412.**

No.	0	1	2	3	4	5	6	7	8	9
100	00000	00043	00087	00130	00173	00217	00260	00303	00346	00389
101	00432	00475	00518	00561	00604	00647	00689	00732	00775	00817
102	00860	00903	00945	00988	01030	01072	01115	01157	01199	01242
103	01284	01326	01368	01410	01452	01494	01536	01578	01620	01662
104	01703	01745	01787	01828	01870	01912	01953	01995	02036	02078
105	02119	02160	02202	02243	02284	02325	02366	02407	02449	02490
106	02531	02572	02612	02653	02694	02735	02776	02816	02857	02898
107	02938	02979	03019	03060	03100	03141	03181	03222	03262	03302
108	03342	03383	03423	03463	03503	03543	03583	03623	03663	03703
109	03743	03782	03822	03862	03902	03941	03981	04021	04060	04100
110	04139	04179	04218	04258	04297	04336	04376	04415	04454	04493
111	04532	04571	04610	04650	04689	04727	04766	04805	04844	04883
112	04922	04961	04999	05038	05077	05115	05154	05192	05231	05269
113	05308	05346	05385	05423	05461	05500	05538	05576	05614	05652
114	05690	05729	05767	05805	05843	05881	05918	05956	05994	06032
115	06070	06108	06145	06183	06221	06258	06296	06333	06371	06408
116	06446	06483	06521	06558	06595	06633	06670	06707	06744	06781
117	06819	06856	06893	06930	06967	07004	07041	07078	07115	07151
118	07188	07225	07262	07298	07335	07372	07408	07445	07482	07518
119	07555	07591	07628	07664	07700	07737	07773	07809	07846	07882
120	07918	07954	07990	08027	08063	08099	08135	08171	08207	08243
121	08279	08314	08350	08386	08422	08458	08493	08529	08565	08600
122	08636	08672	08707	08743	08778	08814	08849	08884	08920	08955
123	08991	09026	09061	09096	09132	09167	09202	09237	09272	09307
124	09342	09377	09412	09447	09482	09517	09552	09587	09621	09656
125	09691	09726	09760	09795	09830	09864	09899	09934	09968	10003
126	10037	10072	10106	10140	10175	10209	10243	10278	10312	10346
127	10380	10415	10449	10483	10517	10551	10585	10619	10653	10687
128	10721	10755	10789	10823	10857	10890	10924	10958	10992	11025
129	11059	11093	11126	11160	11193	11227	11261	11294	11327	11361
130	11394	11428	11461	11494	11528	11561	11594	11628	11661	11694
131	11727	11760	11793	11826	11860	11893	11926	11959	11992	12024
132	12057	12090	12123	12156	12189	12222	12254	12287	12320	12352
133	12385	12418	12450	12483	12516	12548	12581	12613	12646	12678
134	12710	12743	12775	12808	12840	12872	12905	12937	12969	13001
135	13033	13066	13098	13130	13162	13194	13226	13258	13290	13322
136	13354	13386	13418	13450	13481	13513	13545	13577	13609	13640
137	13672	13704	13735	13767	13799	13830	13862	13893	13925	13956
138	13988	14019	14051	14082	14114	14145	14176	14208	14239	14270
139	14301	14333	14364	14395	14426	14457	14489	14520	14551	14582
140	14613	14644	14675	14706	14737	14768	14799	14829	14860	14891
141	14922	14953	14983	15014	15045	15076	15106	15137	15168	15198
142	15229	15259	15290	15320	15351	15381	15412	15442	15473	15503
143	15534	15564	15594	15625	15655	15685	15715	15746	15776	15806
144	15836	15866	15897	15927	15957	15987	16017	16047	16077	16107
145	16137	16167	16197	16227	16256	16286	16316	16346	16376	16406
146	16435	16465	16495	16524	16554	16584	16613	16643	16673	16702
147	16732	16761	16791	16820	16850	16879	16909	16938	16967	16997
148	17026	17056	17085	17114	17143	17173	17202	17231	17260	17289
149	17319	17348	17377	17406	17435	17464	17493	17522	17551	17580
150	17609	17638	17667	17696	17725	17754	17782	17811	17840	17869
151	17898	17926	17955	17984	18013	18041	18070	18099	18127	18156
152	18184	18213	18241	18270	18298	18327	18355	18384	18412	18441
153	18469	18498	18526	18554	18583	18611	18639	18667	18696	18724
154	18752	18780	18808	18837	18865	18893	18921	18949	18977	19005
155	19033	19061	19089	19117	19145	19173	19201	19229	19257	19285
156	19312	19340	19368	19396	19424	19451	19479	19507	19535	19562
157	19590	19618	19645	19673	19700	19728	19756	19783	19811	19838
158	19866	19893	19921	19948	19976	20003	20030	20058	20085	20112
159	20140	20167	20194	20222	20249	20276	20303	20330	20358	20385
No.	0	1	2	3	4	5	6	7	8	9

	43	42
1	4	4
2	9	8
3	13	13
4	17	17
5	22	21
6	26	25
7	30	29
8	34	34
9	39	38

	41	40
1	4	4
2	8	8
3	12	12
4	16	16
5	21	20
6	25	24
7	29	28
8	33	32
9	37	36

	39	38
1	4	4
2	8	8
3	12	11
4	16	15
5	20	19
6	23	23
7	27	27
8	31	30
9	35	34

	37	36
1	4	4
2	7	7
3	11	11
4	15	14
5	19	18
6	22	22
7	26	25
8	30	29
9	33	32

	35	34
1	4	3
2	7	7
3	11	10
4	14	14
5	18	17
6	21	20
7	25	24
8	28	27
9	32	31

	33	32
1	3	3
2	7	6
3	10	10
4	13	13
5	17	16
6	20	19
7	23	22
8	26	26
9	30	29

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 1600———2200. Log. 20412———34242.

No.	0	1	2	3	4	5	6	7	8	9
160	20412	20439	20466	20493	20520	20548	20575	20602	20629	20656
161	20683	20710	20737	20763	20790	20817	20844	20871	20898	20925
162	20952	20978	21005	21032	21059	21085	21112	21139	21165	21192
163	21219	21245	21272	21299	21325	21352	21378	21405	21431	21458
164	21484	21511	21537	21564	21590	21617	21643	21669	21696	21722
165	21748	21775	21801	21827	21854	21880	21906	21932	21958	21985
166	22011	22037	22063	22089	22115	22141	22167	22194	22220	22246
167	22272	22298	22324	22350	22376	22401	22427	22453	22479	22505
168	22531	22557	22583	22608	22634	22660	22686	22712	22737	22763
169	22789	22814	22840	22866	22891	22917	22943	22968	22994	23019
170	23045	23070	23096	23121	23147	23172	23198	23223	23249	23274
171	23300	23325	23350	23376	23401	23426	23452	23477	23502	23528
172	23553	23578	23603	23629	23654	23679	23704	23729	23754	23779
173	23805	23830	23855	23880	23905	23930	23955	23980	24005	24030
174	24055	24080	24105	24130	24155	24180	24204	24229	24254	24279
175	24304	24329	24353	24378	24403	24428	24452	24477	24502	24527
176	24551	24576	24601	24625	24650	24674	24699	24724	24748	24773
177	24797	24822	24846	24871	24895	24920	24944	24969	24993	25018
178	25042	25066	25091	25115	25139	25164	25188	25212	25237	25261
179	25285	25310	25334	25358	25382	25406	25431	25455	25479	25503
180	25527	25551	25575	25600	25624	25648	25672	25696	25720	25744
181	25768	25792	25816	25840	25864	25888	25912	25935	25959	25983
182	26007	26031	26055	26079	26102	26126	26150	26174	26198	26221
183	26245	26269	26293	26316	26340	26364	26387	26411	26435	26458
184	26482	26505	26529	26553	26576	26600	26623	26647	26670	26694
185	26717	26741	26764	26788	26811	26834	26858	26881	26905	26928
186	26951	26975	26998	27021	27045	27068	27091	27114	27138	27161
187	27184	27207	27231	27254	27277	27300	27323	27346	27370	27393
188	27416	27439	27462	27485	27508	27531	27554	27577	27600	27623
189	27646	27669	27692	27715	27738	27761	27784	27807	27830	27852
190	27875	27898	27921	27944	27967	27989	28012	28035	28058	28081
191	28103	28126	28149	28171	28194	28217	28240	28262	28285	28307
192	28330	28353	28375	28398	28421	28443	28466	28488	28511	28533
193	28556	28578	28601	28623	28646	28668	28691	28713	28735	28758
194	28780	28803	28825	28847	28870	28892	28914	28937	28959	28981
195	29003	29026	29048	29070	29092	29115	29137	29159	29181	29203
196	29226	29248	29270	29292	29314	29336	29358	29380	29403	29425
197	29447	29469	29491	29513	29535	29557	29579	29601	29623	29645
198	29667	29688	29710	29732	29754	29776	29798	29820	29842	29863
199	29885	29907	29929	29951	29973	29994	30016	30038	30060	30081
200	30103	30125	30146	30168	30190	30211	30233	30255	30276	30298
201	30320	30341	30363	30384	30406	30428	30449	30471	30492	30514
202	30535	30557	30578	30600	30621	30643	30664	30685	30707	30728
203	30750	30771	30792	30814	30835	30856	30878	30899	30920	30942
204	30963	30984	31006	31027	31048	31069	31091	31112	31133	31154
205	31175	31197	31218	31239	31260	31281	31302	31323	31345	31366
206	31387	31408	31429	31450	31471	31492	31513	31534	31555	31576
207	31597	31618	31639	31660	31681	31702	31723	31744	31765	31785
208	31806	31827	31848	31869	31890	31911	31931	31952	31973	31994
209	32015	32035	32056	32077	32098	32118	32139	32160	32181	32201
210	32222	32243	32263	32284	32305	32325	32346	32366	32387	32408
211	32428	32449	32469	32490	32510	32531	32552	32572	32593	32613
212	32634	32654	32675	32695	32715	32736	32756	32777	32797	32818
213	32838	32858	32879	32899	32919	32940	32960	32980	33001	33021
214	33041	33062	33082	33102	33122	33143	33163	33183	33203	33224
215	33244	33264	33284	33304	33325	33345	33365	33385	33405	33425
216	33445	33465	33486	33506	33526	33546	33566	33586	33606	33626
217	33646	33666	33686	33706	33726	33746	33766	33786	33806	33826
218	33846	33866	33885	33905	33925	33945	33965	33985	34005	34025
219	34044	34064	34084	34104	34124	34143	34163	34183	34203	34223
No.	0	1	2	3	4	5	6	7	8	9

	31	30
1	3	3
2	6	6
3	9	9
4	12	12
5	16	15
6	19	18
7	22	21
8	25	24
9	28	27

	29	28
1	3	3
2	6	6
3	9	8
4	12	11
5	15	14
6	17	17
7	20	20
8	23	22
9	26	25

	27	26
1	3	3
2	5	5
3	8	8
4	11	10
5	14	13
6	16	16
7	19	18
8	22	21
9	24	23

	25	24
1	3	2
2	5	5
3	8	7
4	10	10
5	13	12
6	15	14
7	18	17
8	20	19
9	23	22

	23	22
1	2	2
2	5	4
3	7	7
4	9	9
5	12	11
6	14	13
7	16	15
8	18	18
9	21	20

	21	20
1	2	2
2	4	4
3	6	6
4	8	8
5	11	10
6	13	12
7	15	14
8	17	16
9	19	18

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No 2200——2800. Log. 34242——44716.

No.	0	1	2	3	4	5	6	7	8	9
220	34242	34262	34282	34301	34321	34341	34361	34380	34400	34420
221	34439	34459	34479	34498	34518	34537	34557	34577	34596	34616
222	34635	34655	34674	34694	34713	34733	34753	34772	34792	34811
223	34830	34850	34869	34889	34908	34928	34947	34967	34986	35005
224	35025	35044	35064	35083	35102	35122	35141	35160	35180	35199
225	35218	35238	35257	35276	35295	35315	35334	35353	35372	35392
226	35411	35430	35449	35468	35488	35507	35526	35545	35564	35583
227	35603	35622	35641	35660	35679	35698	35717	35736	35755	35774
228	35793	35813	35832	35851	35870	35889	35908	35927	35946	35965
229	35984	36003	36021	36040	36059	36078	36097	36116	36135	36154
230	36173	36192	36211	36229	36248	36267	36286	36305	36324	36342
231	36361	36380	36399	36418	36436	36455	36474	36493	36511	36530
232	36549	36568	36586	36605	36624	36642	36661	36680	36698	36717
233	36736	36754	36773	36791	36810	36829	36847	36866	36884	36903
234	36922	36940	36959	36977	36996	37014	37033	37051	37070	37088
235	37107	37125	37144	37162	37181	37199	37218	37236	37254	37273
236	37291	37310	37328	37346	37365	37383	37401	37420	37438	37457
237	37475	37493	37511	37530	37548	37566	37585	37603	37621	37639
238	37658	37676	37694	37712	37731	37749	37767	37785	37803	37822
239	37840	37858	37876	37894	37912	37931	37949	37967	37985	38003
240	38021	38039	38057	38075	38093	38112	38130	38148	38166	38184
241	38202	38220	38238	38256	38274	38292	38310	38328	38346	38364
242	38382	38399	38417	38435	38453	38471	38489	38507	38525	38543
243	38561	38578	38596	38614	38632	38650	38668	38686	38703	38721
244	38739	38757	38775	38792	38810	38828	38846	38863	38881	38899
245	38917	38934	38952	38970	38987	39005	39023	39041	39058	39076
246	39094	39111	39129	39146	39164	39182	39199	39217	39235	39252
247	39270	39287	39305	39322	39340	39358	39375	39393	39410	39428
248	39445	39463	39480	39498	39515	39533	39550	39568	39585	39602
249	39620	39637	39655	39672	39690	39707	39724	39742	39759	39777
250	39794	39811	39829	39846	39863	39881	39898	39915	39933	39950
251	39967	39985	40002	40019	40037	40054	40071	40088	40106	40123
252	40140	40157	40175	40192	40209	40226	40243	40261	40278	40295
253	40312	40329	40346	40364	40381	40398	40415	40432	40449	40466
254	40483	40500	40518	40535	40552	40569	40586	40603	40620	40637
255	40654	40671	40688	40705	40722	40739	40756	40773	40790	40807
256	40824	40841	40858	40875	40892	40909	40926	40943	40960	40976
257	40993	41010	41027	41044	41061	41078	41095	41111	41128	41145
258	41162	41179	41196	41212	41229	41246	41263	41280	41296	41313
259	41330	41347	41363	41380	41397	41414	41430	41447	41464	41481
260	41497	41514	41531	41547	41564	41581	41597	41614	41631	41647
261	41664	41681	41697	41714	41731	41747	41764	41780	41797	41814
262	41830	41847	41863	41880	41896	41913	41929	41946	41963	41979
263	41996	42012	42029	42045	42062	42078	42095	42111	42127	42144
264	42160	42177	42193	42210	42226	42243	42259	42275	42292	42308
265	42325	42341	42357	42374	42390	42406	42423	42439	42455	42472
266	42488	42504	42521	42537	42553	42570	42586	42602	42619	42635
267	42651	42667	42684	42700	42716	42732	42749	42765	42781	42797
268	42813	42830	42846	42862	42878	42894	42911	42927	42943	42959
269	42975	42991	43008	43024	43040	43056	43072	43088	43104	43120
270	43136	43152	43169	43185	43201	43217	43233	43249	43265	43281
271	43297	43313	43329	43345	43361	43377	43393	43409	43425	43441
272	43457	43473	43489	43505	43521	43537	43553	43569	43584	43600
273	43616	43632	43648	43664	43680	43696	43712	43727	43743	43759
274	43775	43791	43807	43823	43838	43854	43870	43886	43902	43917
275	43933	43949	43965	43981	43996	44012	44028	44044	44059	44075
276	44091	44107	44122	44138	44154	44170	44185	44201	44217	44232
277	44248	44264	44279	44295	44311	44326	44342	44358	44373	44389
278	44404	44420	44436	44451	44467	44483	44498	44514	44529	44545
279	44560	44576	44592	44607	44623	44638	44654	44669	44685	44700
No.	0	1	2	3	4	5	6	7	8	9

	20	19	18	17	16	15
1	2	2	2	2	2	2
2	4	4	4	3	3	3
3	6	6	5	5	5	5
4	8	8	7	7	6	6
5	10	10	9	9	8	8
6	12	11	11	10	10	9
7	14	13	13	12	11	11
8	16	15	14	14	13	12
9	18	17	16	15	14	14

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 2800——3400. **Log. 44716——53148.**

No.	0	1	2	3	4	5	6	7	8	9
280	44716	44731	44747	44762	44778	44793	44809	44824	44840	44855
281	44871	44886	44902	44917	44932	44948	44963	44979	44994	45010
282	45025	45040	45056	45071	45086	45102	45117	45133	45148	45163
283	45179	45194	45209	45225	45240	45255	45271	45286	45301	45317
284	45332	45347	45362	45378	45393	45408	45423	45439	45454	45469
285	45484	45500	45515	45530	45545	45561	45576	45591	45606	45621
286	45637	45652	45667	45682	45697	45712	45728	45743	45758	45773
287	45788	45803	45818	45834	45849	45864	45879	45894	45909	45924
288	45939	45954	45969	45984	46000	46015	46030	46045	46060	46075
289	46090	46105	46120	46135	46150	46165	46180	46195	46210	46225
290	46240	46255	46270	46285	46300	46315	46330	46345	46359	46374
291	46389	46404	46419	46434	46449	46464	46479	46494	46509	46523
292	46538	46553	46568	46583	46598	46613	46627	46642	46657	46672
293	46687	46702	46716	46731	46746	46761	46776	46790	46805	46820
294	46835	46850	46864	46879	46894	46909	46923	46938	46953	46967
295	46982	46997	47012	47026	47041	47056	47070	47085	47100	47114
296	47129	47144	47159	47173	47188	47202	47217	47232	47246	47261
297	47276	47290	47305	47319	47334	47349	47363	47378	47392	47407
298	47422	47436	47451	47465	47480	47494	47509	47524	47538	47553
299	47567	47582	47596	47611	47625	47640	47654	47669	47683	47698
300	47712	47727	47741	47756	47770	47784	47799	47813	47828	47842
301	47857	47871	47885	47900	47914	47929	47943	47958	47972	47986
302	48001	48015	48029	48044	48058	48073	48087	48101	48116	48130
303	48144	48159	48173	48187	48202	48216	48230	48244	48259	48273
304	48287	48302	48316	48330	48344	48359	48373	48387	48401	48416
305	48430	48444	48458	48473	48487	48501	48515	48530	48544	48558
306	48572	48586	48601	48615	48629	48643	48657	48671	48686	48700
307	48714	48728	48742	48756	48770	48785	48799	48813	48827	48841
308	48855	48869	48883	48897	48911	48926	48940	48954	48968	48982
309	48996	49010	49024	49038	49052	49066	49080	49094	49108	49122
310	49136	49150	49164	49178	49192	49206	49220	49234	49248	49262
311	49276	49290	49304	49318	49332	49346	49360	49374	49388	49402
312	49415	49429	49443	49457	49471	49485	49499	49513	49527	49541
313	49554	49568	49582	49596	49610	49624	49638	49651	49665	49679
314	49693	49707	49721	49734	49748	49762	49776	49790	49803	49817
315	49831	49845	49859	49872	49886	49900	49914	49927	49941	49955
316	49969	49982	49996	50010	50024	50037	50051	50065	50079	50092
317	50106	50120	50133	50147	50161	50174	50188	50202	50215	50229
318	50243	50256	50270	50284	50297	50311	50325	50338	50352	50365
319	50379	50393	50406	50420	50433	50447	50461	50474	50488	50501
320	50515	50529	50542	50556	50569	50583	50596	50610	50623	50637
321	50651	50664	50678	50691	50705	50718	50732	50745	50759	50772
322	50786	50799	50813	50826	50840	50853	50866	50880	50893	50907
323	50920	50934	50947	50961	50974	50987	51001	51014	51028	51041
324	51055	51068	51081	51095	51108	51121	51135	51148	51162	51175
325	51188	51202	51215	51228	51242	51255	51268	51282	51295	51308
326	51322	51335	51348	51362	51375	51388	51402	51415	51428	51441
327	51455	51468	51481	51495	51508	51521	51534	51548	51561	51574
328	51587	51601	51614	51627	51640	51654	51667	51680	51693	51706
329	51720	51733	51746	51759	51772	51786	51799	51812	51825	51838
330	51851	51865	51878	51891	51904	51917	51930	51943	51957	51970
331	51983	51996	52009	52022	52035	52048	52061	52075	52088	52101
332	52114	52127	52140	52153	52166	52179	52192	52205	52218	52231
333	52244	52257	52270	52284	52297	52310	52323	52336	52349	52362
334	52375	52388	52401	52414	52427	52440	52453	52466	52479	52492
335	52504	52517	52530	52543	52556	52569	52582	52595	52608	52621
336	52634	52647	52660	52673	52686	52699	52711	52724	52737	52750
337	52763	52776	52789	52802	52815	52827	52840	52853	52866	52879
338	52892	52905	52917	52930	52943	52956	52969	52982	52994	53007
339	53020	53033	53046	53058	53071	53084	53097	53110	53122	53135
No.	0	1	2	3	4	5	6	7	8	9

16	
1	2
2	
3	5
4	6
5	8
6	10
7	11
8	13
9	14

15	
1	2
2	3
3	5
4	6
5	8
6	9
7	11
8	12
9	14

14	
1	1
2	3
3	4
4	6
5	7
6	8
7	10
8	11
9	13

13	
1	1
2	3
3	4
4	5
5	7
6	8
7	9
8	10
9	12

12	
1	1
2	2
3	4
4	5
5	6
6	7
7	8
8	10
9	11

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 3400——4000. Log. 53148——60206.

No.	0	1	2	3	4	5	6	7	8	9
340	53148	53161	53173	53186	53199	53212	53224	53237	53250	53263
341	53275	53288	53301	53314	53326	53339	53352	53364	53377	53390
342	53403	53415	53428	53441	53453	53466	53479	53491	53504	53517
343	53529	53542	53555	53567	53580	53593	53605	53618	53631	53643
344	53656	53668	53681	53694	53706	53719	53732	53744	53757	53769
345	53782	53794	53807	53820	53832	53845	53857	53870	53882	53895
346	53908	53920	53933	53945	53958	53970	53983	53995	54008	54020
347	54033	54045	54058	54070	54083	54095	54108	54120	54133	54145
348	54158	54170	54183	54195	54208	54220	54233	54245	54258	54270
349	54283	54295	54307	54320	54332	54345	54357	54370	54382	54394
350	54407	54419	54432	54444	54456	54469	54481	54494	54506	54518
351	54531	54543	54555	54568	54580	54593	54605	54617	54630	54642
352	54654	54667	54679	54691	54704	54716	54728	54741	54753	54765
353	54777	54790	54802	54814	54827	54839	54851	54864	54876	54888
354	54900	54913	54925	54937	54949	54962	54974	54986	54998	55011
355	55023	55035	55047	55060	55072	55084	55096	55108	55121	55133
356	55145	55157	55169	55182	55194	55206	55218	55230	55242	55255
357	55267	55279	55291	55303	55315	55328	55340	55352	55364	55376
358	55388	55400	55413	55425	55437	55449	55461	55473	55485	55497
359	55509	55522	55534	55546	55558	55570	55582	55594	55606	55618
360	55630	55642	55654	55666	55678	55691	55703	55715	55727	55739
361	55751	55763	55775	55787	55799	55811	55823	55835	55847	55859
362	55871	55883	55895	55907	55919	55931	55943	55955	55967	55979
363	55991	56003	56015	56027	56038	56050	56062	56074	56086	56098
364	56110	56122	56134	56146	56158	56170	56182	56194	56205	56217
365	56229	56241	56253	56265	56277	56289	56301	56312	56324	56336
366	56348	56360	56372	56384	56396	56407	56419	56431	56443	56455
367	56467	56478	56490	56502	56514	56526	56538	56549	56561	56573
368	56585	56597	56608	56620	56632	56644	56656	56667	56679	56691
369	56703	56714	56726	56738	56750	56761	56773	56785	56797	56808
370	56820	56832	56844	56855	56867	56879	56891	56902	56914	56926
371	56937	56949	56961	56972	56984	56996	57008	57019	57031	57043
372	57054	57066	57078	57089	57101	57113	57124	57136	57148	57159
373	57171	57183	57194	57206	57217	57229	57241	57252	57264	57276
374	57287	57299	57310	57322	57334	57345	57357	57368	57380	57392
375	57403	57415	57426	57438	57449	57461	57473	57484	57496	57507
376	57519	57530	57542	57553	57565	57576	57588	57600	57611	57623
377	57634	57646	57657	57669	57680	57692	57703	57715	57726	57738
378	57749	57761	57772	57784	57795	57807	57818	57830	57841	57852
379	57864	57875	57887	57898	57910	57921	57933	57944	57955	57967
380	57978	57990	58001	58013	58024	58035	58047	58058	58070	58081
381	58092	58104	58115	58127	58138	58149	58161	58172	58184	58195
382	58206	58218	58229	58240	58252	58263	58274	58286	58297	58309
383	58320	58331	58343	58354	58365	58377	58388	58399	58410	58422
384	58433	58444	58456	58467	58478	58490	58501	58512	58524	58535
385	58546	58557	58569	58580	58591	58602	58614	58625	58636	58647
386	58659	58670	58681	58692	58704	58715	58726	58737	58749	58760
387	58771	58782	58794	58805	58816	58827	58838	58850	58861	58872
388	58883	58894	58906	58917	58928	58939	58950	58961	58973	58984
389	58995	59006	59017	59028	59040	59051	59062	59073	59084	59095
390	59106	59118	59129	59140	59151	59162	59173	59184	59195	59207
391	59218	59229	59240	59251	59262	59273	59284	59295	59306	59318
392	59329	59340	59351	59362	59373	59384	59395	59406	59417	59428
393	59439	59450	59461	59472	59483	59494	59506	59517	59528	59539
394	59550	59561	59572	59583	59594	59605	59616	59627	59638	59649
395	59660	59671	59682	59693	59704	59715	59726	59737	59748	59759
396	59770	59780	59791	59802	59813	59824	59835	59846	59857	59868
397	59879	59890	59901	59912	59923	59934	59945	59956	59966	59977
398	59988	59999	60010	60021	60032	60043	60054	60065	60076	60086
399	60097	60108	60119	60130	60141	60152	60163	60173	60184	60195
No.	0	1	2	3	4	5	6	7	8	9

13	
1	1
2	3
3	4
4	5
5	7
6	8
7	9
8	10
9	12

12	
1	1
2	2
3	4
4	5
5	6
6	7
7	8
8	10
9	11

11	
1	1
2	2
3	3
4	4
5	6
6	7
7	8
8	9
9	10

10	
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 4000——4600. Log. 60206——66276.

No.	0	1	2	3	4	5	6	7	8	9
400	60206	60217	60228	60239	60249	60260	60271	60282	60293	60304
401	60314	60325	60336	60347	60358	60369	60379	60390	60401	60412
402	60423	60433	60444	60455	60466	60477	60487	60498	60509	60520
403	60531	60541	60552	60563	60574	60584	60595	60606	60617	60627
404	60638	60649	60660	60670	60681	60692	60703	60713	60724	60735
405	60746	60756	60767	60778	60788	60799	60810	60821	60831	60842
406	60853	60863	60874	60885	60895	60906	60917	60927	60938	60949
407	60959	60970	60981	60991	61002	61013	61023	61034	61045	61055
408	61066	61077	61087	61098	61109	61119	61130	61140	61151	61162
409	61172	61183	61194	61204	61215	61225	61236	61247	61257	61268
410	61278	61289	61300	61310	61321	61331	61342	61352	61363	61374
411	61384	61395	61405	61416	61426	61437	61448	61458	61469	61479
412	61490	61500	61511	61521	61532	61542	61553	61563	61574	61584
413	61595	61606	61616	61627	61637	61648	61658	61669	61679	61690
414	61700	61711	61721	61731	61742	61752	61763	61773	61784	61794
415	61805	61815	61826	61836	61847	61857	61868	61878	61888	61899
416	61909	61920	61930	61941	61951	61962	61972	61982	61993	62003
417	62014	62024	62034	62045	62055	62066	62076	62086	62097	62107
418	62118	62128	62138	62149	62159	62170	62180	62190	62201	62211
419	62221	62232	62242	62252	62263	62273	62284	62294	62304	62315
420	62325	62335	62346	62356	62366	62377	62387	62397	62408	62418
421	62428	62439	62449	62459	62469	62480	62490	62500	62511	62521
422	62531	62542	62552	62562	62572	62583	62593	62603	62613	62624
423	62634	62644	62655	62665	62675	62685	62696	62706	62716	62726
424	62737	62747	62757	62767	62778	62788	62798	62808	62818	62829
425	62839	62849	62859	62870	62880	62890	62900	62910	62921	62931
426	62941	62951	62961	62972	62982	62992	63002	63012	63022	63033
427	63043	63053	63063	63073	63083	63094	63104	63114	63124	63134
428	63144	63155	63165	63175	63185	63195	63205	63215	63225	63236
429	63246	63256	63266	63276	63286	63296	63306	63317	63327	63337
430	63347	63357	63367	63377	63387	63397	63407	63417	63428	63438
431	63448	63458	63468	63478	63488	63498	63508	63518	63528	63538
432	63548	63558	63568	63579	63589	63599	63609	63619	63629	63639
433	63649	63659	63669	63679	63689	63699	63709	63719	63729	63739
434	63749	63759	63769	63779	63789	63799	63809	63819	63829	63839
435	63849	63859	63869	63879	63889	63899	63909	63919	63929	63939
436	63949	63959	63969	63979	63988	63998	64008	64018	64028	64038
437	64048	64058	64068	64078	64088	64098	64108	64118	64128	64137
438	64147	64157	64167	64177	64187	64197	64207	64217	64227	64237
439	64246	64256	64266	64276	64286	64296	64306	64316	64326	64335
440	64345	64355	64365	64375	64385	64395	64404	64414	64424	64434
441	64444	64454	64464	64473	64483	64493	64503	64513	64523	64532
442	64542	64552	64562	64572	64582	64591	64601	64611	64621	64631
443	64640	64650	64660	64670	64680	64689	64699	64709	64719	64729
444	64738	64748	64758	64768	64777	64787	64797	64807	64816	64826
445	64836	64846	64856	64865	64875	64885	64895	64904	64914	64924
446	64933	64943	64953	64963	64972	64982	64992	65002	65011	65021
447	65031	65040	65050	65060	65070	65079	65089	65099	65108	65118
448	65128	65137	65147	65157	65167	65176	65186	65196	65205	65215
449	65225	65234	65244	65254	65263	65273	65283	65292	65302	65312
450	65321	65331	65341	65350	65360	65369	65379	65389	65398	65408
451	65418	65427	65437	65447	65456	65466	65475	65485	65495	65504
452	65514	65523	65533	65543	65552	65562	65571	65581	65591	65600
453	65610	65619	65629	65639	65648	65658	65667	65677	65686	65696
454	65706	65715	65725	65734	65744	65753	65763	65772	65782	65792
455	65801	65811	65820	65830	65839	65849	65858	65868	65877	65887
456	65896	65906	65916	65925	65935	65944	65954	65963	65973	65982
457	65992	66001	66011	66020	66030	66039	66049	66058	66068	66077
458	66087	66096	66106	66115	66124	66134	66143	66153	66162	66172
459	66181	66191	66200	66210	66219	66229	66238	66247	66257	66266
No.	0	1	2	3	4	5	6	7	8	9

11	
1	1
2	2
3	3
4	4
5	6
6	7
7	8
8	9
9	10

10	
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

9	
1	1
2	2
3	3
4	4
5	5
6	5
7	6
8	7
9	8

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 4600——5200. Log. 66276——71600.

No.	0	1	2	3	4	5	6	7	8	9
460	66276	66285	66295	66304	66314	66323	66332	66342	66351	66361
461	66370	66380	66389	66398	66408	66417	66427	66436	66445	66455
462	66464	66474	66483	66492	66502	66511	66521	66530	66539	66549
463	66558	66567	66577	66586	66596	66605	66614	66624	66633	66642
464	66652	66661	66671	66680	66689	66699	66708	66717	66727	66736
465	66745	66755	66764	66773	66783	66792	66801	66811	66820	66829
466	66839	66848	66857	66867	66876	66885	66894	66904	66913	66922
467	66932	66941	66950	66960	66969	66978	66987	66997	67006	67015
468	67025	67034	67043	67052	67062	67071	67080	67089	67099	67108
469	67117	67127	67136	67145	67154	67164	67173	67182	67191	67201
470	67210	67219	67228	67237	67247	67256	67265	67274	67284	67293
471	67302	67311	67321	67330	67339	67348	67357	67367	67376	67385
472	67394	67403	67413	67422	67431	67440	67449	67459	67468	67477
473	67486	67495	67504	67514	67523	67532	67541	67550	67560	67569
474	67578	67587	67596	67605	67614	67624	67633	67642	67651	67660
475	67669	67679	67688	67697	67706	67715	67724	67733	67742	67752
476	67761	67770	67779	67788	67797	67806	67815	67825	67834	67843
477	67852	67861	67870	67879	67888	67897	67906	67916	67925	67934
478	67943	67952	67961	67970	67979	67988	67997	68006	68015	68024
479	68034	68043	68052	68061	68070	68079	68088	68097	68106	68115
480	68124	68133	68142	68151	68160	68169	68178	68187	68196	68205
481	68215	68224	68233	68242	68251	68260	68269	68278	68287	68296
482	68305	68314	68323	68332	68341	68350	68359	68368	68377	68386
483	68395	68404	68413	68422	68431	68440	68449	68458	68467	68476
484	68485	68494	68502	68511	68520	68529	68538	68547	68556	68565
485	68574	68583	68592	68601	68610	68619	68628	68637	68646	68655
486	68664	68673	68681	68690	68699	68708	68717	68726	68735	68744
487	68753	68762	68771	68780	68789	68797	68806	68815	68824	68833
488	68842	68851	68860	68869	68878	68886	68895	68904	68913	68922
489	68931	68940	68949	68958	68966	68975	68984	68993	69002	69011
490	69020	69028	69037	69046	69055	69064	69073	69082	69090	69099
491	69108	69117	69126	69135	69144	69152	69161	69170	69179	69188
492	69197	69205	69214	69223	69232	69241	69249	69258	69267	69276
493	69285	69294	69302	69311	69320	69329	69338	69346	69355	69364
494	69373	69381	69390	69399	69408	69417	69425	69434	69443	69452
495	69461	69469	69478	69487	69496	69504	69513	69522	69531	69539
496	69548	69557	69566	69574	69583	69592	69601	69609	69618	69627
497	69636	69644	69653	69662	69671	69679	69688	69697	69705	69714
498	69723	69732	69740	69749	69758	69767	69775	69784	69793	69801
499	69810	69819	69827	69836	69845	69854	69862	69871	69880	69888
500	69897	69906	69914	69923	69932	69940	69949	69958	69966	69975
501	69984	69992	70001	70010	70018	70027	70036	70044	70053	70062
502	70070	70079	70088	70096	70105	70114	70122	70131	70140	70148
503	70157	70165	70174	70183	70191	70200	70209	70217	70226	70234
504	70243	70252	70260	70269	70278	70286	70295	70303	70312	70321
505	70329	70338	70346	70355	70364	70372	70381	70389	70398	70406
506	70415	70424	70432	70441	70449	70458	70467	70475	70484	70492
507	70501	70509	70518	70526	70535	70544	70552	70561	70569	70578
508	70586	70595	70603	70612	70621	70629	70638	70646	70655	70663
509	70672	70680	70689	70697	70706	70714	70723	70731	70740	70749
510	70757	70766	70774	70783	70791	70800	70808	70817	70825	70834
511	70842	70851	70859	70868	70876	70885	70893	70902	70910	70919
512	70927	70935	70944	70952	70961	70969	70978	70986	70995	71003
513	71012	71020	71029	71037	71046	71054	71063	71071	71079	71088
514	71096	71105	71113	71122	71130	71139	71147	71155	71164	71172
515	71181	71189	71198	71206	71214	71223	71231	71240	71248	71257
516	71265	71273	71282	71290	71299	71307	71315	71324	71332	71341
517	71349	71357	71366	71374	71383	71391	71399	71408	71416	71425
518	71433	71441	71450	71458	71466	71475	71483	71492	71500	71508
519	71517	71525	71533	71542	71550	71559	71567	71575	71584	71592
No.	0	1	2	3	4	5	6	7	8	9

10	
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

9	
1	1
2	2
3	3
4	4
5	5
6	5
7	6
8	7
9	8

8	
1	1
2	2
3	2
4	3
5	4
6	5
7	6
8	6
9	7

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 5200——5800. Log. 71600——76343.

No.	0	1	2	3	4	5	6	7	8	9
520	71600	71609	71617	71625	71634	71642	71650	71659	71667	71675
521	71684	71692	71700	71709	71717	71725	71734	71742	71750	71759
522	71767	71775	71784	71792	71800	71809	71817	71825	71834	71842
523	71850	71858	71867	71875	71883	71892	71900	71908	71917	71925
524	71933	71941	71950	71958	71966	71975	71983	71991	71999	72008
525	72016	72024	72032	72041	72049	72057	72066	72074	72082	72090
526	72099	72107	72115	72123	72132	72140	72148	72156	72165	72173
527	72181	72189	72198	72206	72214	72222	72230	72239	72247	72255
528	72263	72272	72280	72288	72296	72304	72313	72321	72329	72337
529	72346	72354	72362	72370	72378	72387	72395	72403	72411	72419
530	72428	72436	72444	72452	72460	72469	72477	72485	72493	72501
531	72509	72518	72526	72534	72542	72550	72558	72567	72575	72583
532	72591	72599	72607	72616	72624	72632	72640	72648	72656	72665
533	72673	72681	72689	72697	72705	72713	72722	72730	72738	72746
534	72754	72762	72770	72779	72787	72795	72803	72811	72819	72827
535	72835	72843	72852	72860	72868	72876	72884	72892	72900	72908
536	72916	72925	72933	72941	72949	72957	72965	72973	72981	72989
537	72997	73006	73014	73022	73030	73038	73046	73054	73062	73070
538	73078	73086	73094	73102	73111	73119	73127	73135	73143	73151
539	73159	73167	73175	73183	73191	73199	73207	73215	73223	73231
540	73239	73247	73255	73263	73272	73280	73288	73296	73304	73312
541	73320	73328	73336	73344	73352	73360	73368	73376	73384	73392
542	73400	73408	73416	73424	73432	73440	73448	73456	73464	73472
543	73480	73488	73496	73504	73512	73520	73528	73536	73544	73552
544	73560	73568	73576	73584	73592	73600	73608	73616	73624	73632
545	73640	73648	73656	73664	73672	73679	73687	73695	73703	73711
546	73719	73727	73735	73743	73751	73759	73767	73775	73783	73791
547	73799	73807	73815	73823	73830	73838	73846	73854	73862	73870
548	73878	73886	73894	73902	73910	73918	73926	73933	73941	73949
549	73957	73965	73973	73981	73989	73997	74005	74013	74020	74028
550	74036	74044	74052	74060	74068	74076	74084	74092	74099	74107
551	74115	74123	74131	74139	74147	74155	74162	74170	74178	74186
552	74194	74202	74210	74218	74225	74233	74241	74249	74257	74265
553	74273	74280	74288	74296	74304	74312	74320	74327	74335	74343
554	74351	74359	74367	74374	74382	74390	74398	74406	74414	74421
555	74429	74437	74445	74453	74461	74468	74476	74484	74492	74500
556	74507	74515	74523	74531	74539	74547	74554	74562	74570	74578
557	74586	74593	74601	74609	74617	74624	74632	74640	74648	74656
558	74663	74671	74679	74687	74695	74702	74710	74718	74726	74733
559	74741	74749	74757	74764	74772	74780	74788	74796	74803	74811
560	74819	74827	74834	74842	74850	74858	74865	74873	74881	74889
561	74896	74904	74912	74920	74927	74935	74943	74950	74958	74966
562	74974	74981	74989	74997	75005	75012	75020	75028	75035	75043
563	75051	75059	75066	75074	75082	75089	75097	75105	75113	75120
564	75128	75136	75143	75151	75159	75166	75174	75182	75189	75197
565	75205	75213	75220	75228	75236	75243	75251	75259	75266	75274
566	75282	75289	75297	75305	75312	75320	75328	75335	75343	75351
567	75358	75366	75374	75381	75389	75397	75404	75412	75420	75427
568	75435	75442	75450	75458	75465	75473	75481	75488	75496	75504
569	75511	75519	75526	75534	75542	75549	75557	75565	75572	75580
570	75587	75595	75603	75610	75618	75626	75633	75641	75648	75656
571	75664	75671	75679	75686	75694	75702	75709	75717	75724	75732
572	75740	75747	75755	75762	75770	75778	75785	75793	75800	75808
573	75815	75823	75831	75838	75846	75853	75861	75868	75876	75884
574	75891	75899	75906	75914	75921	75929	75937	75944	75952	75959
575	75967	75974	75982	75989	75997	76005	76012	76020	76027	76035
576	76042	76050	76057	76065	76072	76080	76087	76095	76103	76110
577	76118	76125	76133	76140	76148	76155	76163	76170	76178	76185
578	76193	76200	76208	76215	76223	76230	76238	76245	76253	76260
579	76268	76275	76283	76290	76298	76305	76313	76320	76328	76335
No.	0	1	2	3	4	5	6	7	8	9

9	
1	1
2	2
3	3
4	4
5	5
6	5
7	6
8	7
9	8

8	
1	1
2	2
3	2
4	3
5	4
6	5
7	6
8	6
9	7

7	
1	1
2	1
3	2
4	3
5	4
6	4
7	5
8	6
9	6

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 5800——6400. Log. 76343——80618.

No.	0	1	2	3	4	5	6	7	8	9
580	76343	76350	76358	76365	76373	76380	76388	76395	76403	76410
581	76418	76425	76433	76440	76448	76455	76462	76470	76477	76485
582	76492	76500	76507	76515	76522	76530	76537	76545	76552	76559
583	76567	76574	76582	76589	76597	76604	76612	76619	76626	76634
584	76641	76649	76656	76664	76671	76678	76686	76693	76701	76708
585	76716	76723	76730	76738	76745	76753	76760	76768	76775	76782
586	76790	76797	76805	76812	76819	76827	76834	76842	76849	76856
587	76864	76871	76879	76886	76893	76901	76908	76916	76923	76930
588	76938	76945	76953	76960	76967	76975	76982	76989	76997	77004
589	77012	77019	77026	77034	77041	77048	77056	77063	77070	77078
590	77085	77093	77100	77107	77115	77122	77129	77137	77144	77151
591	77159	77166	77173	77181	77188	77195	77203	77210	77217	77225
592	77232	77240	77247	77254	77262	77269	77276	77283	77291	77298
593	77305	77313	77320	77327	77335	77342	77349	77357	77364	77371
594	77379	77386	77393	77401	77408	77415	77422	77430	77437	77444
595	77452	77459	77466	77474	77481	77488	77495	77503	77510	77517
596	77525	77532	77539	77546	77554	77561	77568	77576	77583	77590
597	77597	77605	77612	77619	77627	77634	77641	77648	77656	77663
598	77670	77677	77685	77692	77699	77706	77714	77721	77728	77735
599	77743	77750	77757	77764	77772	77779	77786	77793	77801	77808
600	77815	77822	77830	77837	77844	77851	77859	77866	77873	77880
601	77887	77895	77902	77909	77916	77924	77931	77938	77945	77952
602	77960	77967	77974	77981	77988	77996	78003	78010	78017	78025
603	78032	78039	78046	78053	78061	78068	78075	78082	78089	78097
604	78104	78111	78118	78125	78132	78140	78147	78154	78161	78168
605	78176	78183	78190	78197	78204	78211	78219	78226	78233	78240
606	78247	78254	78262	78269	78276	78283	78290	78297	78305	78312
607	78319	78326	78333	78340	78347	78355	78362	78369	78376	78383
608	78390	78398	78405	78412	78419	78426	78433	78440	78447	78455
609	78462	78469	78476	78483	78490	78497	78504	78512	78519	78526
610	78533	78540	78547	78554	78561	78569	78576	78583	78590	78597
611	78604	78611	78618	78625	78633	78640	78647	78654	78661	78668
612	78675	78682	78689	78696	78704	78711	78718	78725	78732	78739
613	78746	78753	78760	78767	78774	78781	78789	78796	78803	78810
614	78817	78824	78831	78838	78845	78852	78859	78866	78873	78880
615	78888	78895	78902	78909	78916	78923	78930	78937	78944	78951
616	78958	78965	78972	78979	78986	78993	79000	79007	79014	79021
617	79029	79036	79043	79050	79057	79064	79071	79078	79085	79092
618	79099	79106	79113	79120	79127	79134	79141	79148	79155	79162
619	79169	79176	79183	79190	79197	79204	79211	79218	79225	79232
620	79239	79246	79253	79260	79267	79274	79281	79288	79295	79302
621	79309	79316	79323	79330	79337	79344	79351	79358	79365	79372
622	79379	79386	79393	79400	79407	79414	79421	79428	79435	79442
623	79449	79456	79463	79470	79477	79484	79491	79498	79505	79511
624	79518	79525	79532	79539	79546	79553	79560	79567	79574	79581
625	79588	79595	79602	79609	79616	79623	79630	79637	79644	79650
626	79657	79664	79671	79678	79685	79692	79699	79706	79713	79720
627	79727	79734	79741	79748	79754	79761	79768	79775	79782	79789
628	79796	79803	79810	79817	79824	79831	79837	79844	79851	79858
629	79865	79872	79879	79886	79893	79900	79906	79913	79920	79927
630	79934	79941	79948	79955	79962	79969	79975	79982	79989	79996
631	80003	80010	80017	80024	80030	80037	80044	80051	80058	80065
632	80072	80079	80085	80092	80099	80106	80113	80120	80127	80134
633	80140	80147	80154	80161	80168	80175	80182	80188	80195	80202
634	80209	80216	80223	80229	80236	80243	80250	80257	80264	80271
635	80277	80284	80291	80298	80305	80312	80318	80325	80332	80339
636	80346	80353	80359	80366	80373	80380	80387	80393	80400	80407
637	80414	80421	80428	80434	80441	80448	80455	80462	80468	80475
638	80482	80489	80496	80502	80509	80516	80523	80530	80536	80543
639	80550	80557	80564	80570	80577	80584	80591	80598	80604	80611
No.	0	1	2	3	4	5	6	7	8	9

8	
1	1
2	2
3	2
4	3
5	4
6	5
7	6
8	6
9	7

7	
1	1
2	1
3	2
4	3
5	4
6	4
7	5
8	6
9	6

6	
1	1
2	1
3	2
4	2
5	3
6	4
7	4
8	5
9	5

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 6400——7000. **Log. 80618——84510.**

No.	0	1	2	3	4	5	6	7	8	9
640	80618	80625	80632	80638	80645	80652	80659	80665	80672	80679
641	80686	80693	80699	80706	80713	80720	80726	80733	80740	80747
642	80754	80760	80767	80774	80781	80787	80794	80801	80808	80814
643	80821	80828	80835	80841	80848	80855	80862	80868	80875	80882
644	80889	80895	80902	80909	80916	80922	80929	80936	80943	80949
645	80956	80963	80969	80976	80983	80990	80996	81003	81010	81017
646	81023	81030	81037	81043	81050	81057	81064	81070	81077	81084
647	81090	81097	81104	81111	81117	81124	81131	81137	81144	81151
648	81158	81164	81171	81178	81184	81191	81198	81204	81211	81218
649	81224	81231	81238	81245	81251	81258	81265	81271	81278	81285
650	81291	81298	81305	81311	81318	81325	81331	81338	81345	81351
651	81358	81365	81371	81378	81385	81391	81398	81405	81411	81418
652	81425	81431	81438	81445	81451	81458	81465	81471	81478	81485
653	81491	81498	81505	81511	81518	81525	81531	81538	81544	81551
654	81558	81564	81571	81578	81584	81591	81598	81604	81611	81617
655	81624	81631	81637	81644	81651	81657	81664	81671	81677	81684
656	81690	81697	81704	81710	81717	81723	81730	81737	81743	81750
657	81757	81763	81770	81776	81783	81790	81796	81803	81809	81816
658	81823	81829	81836	81842	81849	81856	81862	81869	81875	81882
659	81889	81895	81902	81908	81915	81921	81928	81935	81941	81948
660	81954	81961	81968	81974	81981	81987	81994	82000	82007	82014
661	82020	82027	82033	82040	82046	82053	82060	82066	82073	82079
662	82086	82092	82099	82105	82112	82119	82125	82132	82138	82145
663	82151	82158	82164	82171	82178	82184	82191	82197	82204	82210
664	82217	82223	82230	82236	82243	82249	82256	82263	82269	82276
665	82282	82289	82295	82302	82308	82315	82321	82328	82334	82341
666	82347	82354	82360	82367	82373	82380	82387	82393	82400	82406
667	82413	82419	82426	82432	82439	82445	82452	82458	82465	82471
668	82478	82484	82491	82497	82504	82510	82517	82523	82530	82536
669	82543	82549	82556	82562	82569	82575	82582	82588	82595	82601
670	82607	82614	82620	82627	82633	82640	82646	82653	82659	82666
671	82672	82679	82685	82692	82698	82705	82711	82718	82724	82730
672	82737	82743	82750	82756	82763	82769	82776	82782	82789	82795
673	82802	82808	82814	82821	82827	82834	82840	82847	82853	82860
674	82866	82872	82879	82885	82892	82898	82905	82911	82918	82924
675	82930	82937	82943	82950	82956	82963	82969	82975	82982	82988
676	82995	83001	83008	83014	83020	83027	83033	83040	83046	83052
677	83059	83065	83072	83078	83085	83091	83097	83104	83110	83117
678	83123	83129	83136	83142	83149	83155	83161	83168	83174	83181
679	83187	83193	83200	83206	83213	83219	83225	83232	83238	83245
680	83251	83257	83264	83270	83276	83283	83289	83296	83302	83308
681	83315	83321	83327	83334	83340	83347	83353	83359	83366	83372
682	83378	83385	83391	83398	83404	83410	83417	83423	83429	83436
683	83442	83448	83455	83461	83467	83474	83480	83487	83493	83499
684	83506	83512	83518	83525	83531	83537	83544	83550	83556	83563
685	83569	83575	83582	83588	83594	83601	83607	83613	83620	83626
686	83632	83639	83645	83651	83658	83664	83670	83677	83683	83689
687	83696	83702	83708	83715	83721	83727	83734	83740	83746	83753
688	83759	83765	83771	83778	83784	83790	83797	83803	83809	83816
689	83822	83828	83835	83841	83847	83853	83860	83866	83872	83879
690	83885	83891	83897	83904	83910	83916	83923	83929	83935	83942
691	83948	83954	83960	83967	83973	83979	83985	83992	83998	84004
692	84011	84017	84023	84029	84036	84042	84048	84055	84061	84067
693	84073	84080	84086	84092	84098	84105	84111	84117	84123	84130
694	84136	84142	84148	84155	84161	84167	84173	84180	84186	84192
695	84198	84205	84211	84217	84223	84230	84236	84242	84248	84255
696	84261	84267	84273	84280	84286	84292	84298	84305	84311	84317
697	84323	84330	84336	84342	84348	84354	84361	84367	84373	84379
698	84386	84392	84398	84404	84410	84417	84423	84429	84435	84442
699	84448	84454	84460	84466	84473	84479	84485	84491	84497	84504
No.	0	1	2	3	4	5	6	7	8	9

7	
1	1
2	1
3	2
4	3
5	4
6	4
7	5
8	6
9	6

6	
1	1
2	1
3	2
4	2
5	3
6	4
7	4
8	5
9	5

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 7000——7600. Log. 84510——88081.

No.	0	1	2	3	4	5	6	7	8	9
700	84510	84516	84522	84528	84535	84541	84547	84553	84559	84566
701	84572	84578	84584	84590	84597	84603	84609	84615	84621	84628
702	84634	84640	84646	84652	84658	84665	84671	84677	84683	84689
703	84696	84702	84708	84714	84720	84726	84733	84739	84745	84751
704	84757	84763	84770	84776	84782	84788	84794	84800	84807	84813
705	84819	84825	84831	84837	84844	84850	84856	84862	84868	84874
706	84880	84887	84893	84899	84905	84911	84917	84924	84930	84936
707	84942	84948	84954	84960	84967	84973	84979	84985	84991	84997
708	85003	85009	85016	85022	85028	85034	85040	85046	85052	85058
709	85065	85071	85077	85083	85089	85095	85101	85107	85114	85120
710	85126	85132	85138	85144	85150	85156	85163	85169	85175	85181
711	85187	85193	85199	85205	85211	85217	85224	85230	85236	85242
712	85248	85254	85260	85266	85272	85278	85285	85291	85297	85303
713	85309	85315	85321	85327	85333	85339	85345	85352	85358	85364
714	85370	85376	85382	85388	85394	85400	85406	85412	85418	85425
715	85431	85437	85443	85449	85455	85461	85467	85473	85479	85485
716	85491	85497	85503	85509	85516	85522	85528	85534	85540	85546
717	85552	85558	85564	85570	85576	85582	85588	85594	85600	85606
718	85612	85618	85625	85631	85637	85643	85649	85655	85661	85667
719	85673	85679	85685	85691	85697	85703	85709	85715	85721	85727
720	85733	85739	85745	85751	85757	85763	85769	85775	85781	85788
721	85794	85800	85806	85812	85818	85824	85830	85836	85842	85848
722	85854	85860	85866	85872	85878	85884	85890	85896	85902	85908
723	85914	85920	85926	85932	85938	85944	85950	85956	85962	85968
724	85974	85980	85986	85992	85998	86004	86010	86016	86022	86028
725	86034	86040	86046	86052	86058	86064	86070	86076	86082	86088
726	86094	86100	86106	86112	86118	86124	86130	86136	86141	86147
727	86153	86159	86165	86171	86177	86183	86189	86195	86201	86207
728	86213	86219	86225	86231	86237	86243	86249	86255	86261	86267
729	86273	86279	86285	86291	86297	86303	86308	86314	86320	86326
730	86332	86338	86344	86350	86356	86362	86368	86374	86380	86386
731	86392	86398	86404	86410	86415	86421	86427	86433	86439	86445
732	86451	86457	86463	86469	86475	86481	86487	86493	86499	86504
733	86510	86516	86522	86528	86534	86540	86546	86552	86558	86564
734	86570	86576	86581	86587	86593	86599	86605	86611	86617	86623
735	86629	86635	86641	86646	86652	86658	86664	86670	86676	86682
736	86688	86694	86700	86705	86711	86717	86723	86729	86735	86741
737	86747	86753	86759	86764	86770	86776	86782	86788	86794	86800
738	86806	86812	86817	86823	86829	86835	86841	86847	86853	86859
739	86864	86870	86876	86882	86888	86894	86900	86906	86911	86917
740	86923	86929	86935	86941	86947	86953	86958	86964	86970	86976
741	86982	86988	86994	86999	87005	87011	87017	87023	87029	87035
742	87040	87046	87052	87058	87064	87070	87075	87081	87087	87093
743	87099	87105	87111	87116	87122	87128	87134	87140	87146	87151
744	87157	87163	87169	87175	87181	87186	87192	87198	87204	87210
745	87216	87221	87227	87233	87239	87245	87251	87256	87262	87268
746	87274	87280	87286	87291	87297	87303	87309	87315	87320	87326
747	87332	87338	87344	87349	87355	87361	87367	87373	87379	87384
748	87390	87396	87402	87408	87413	87419	87425	87431	87437	87442
749	87448	87454	87460	87466	87471	87477	87483	87489	87495	87500
750	87506	87512	87518	87523	87529	87535	87541	87547	87552	87558
751	87564	87570	87576	87581	87587	87593	87599	87604	87610	87616
752	87622	87628	87633	87639	87645	87651	87656	87662	87668	87674
753	87679	87685	87691	87697	87703	87708	87714	87720	87726	87731
754	87737	87743	87749	87754	87760	87766	87772	87777	87783	87789
755	87795	87800	87806	87812	87818	87823	87829	87835	87841	87846
756	87852	87858	87864	87869	87875	87881	87887	87892	87898	87904
757	87910	87915	87921	87927	87933	87938	87944	87950	87955	87961
758	87967	87973	87978	87984	87990	87996	88001	88007	88013	88018
759	88024	88030	88036	88041	88047	88053	88058	88064	88070	88076
No.	0	1	2	3	4	5	6	7	8	9

7	
1	1
2	1
3	2
4	3
5	4
6	4
7	5
8	6
9	6

6	
1	1
2	1
3	2
4	2
5	3
6	4
7	4
8	5
9	5

5	
1	1
2	1
3	2
4	2
5	3
6	3
7	4
8	4
9	5

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 7600——8200. **Log. 88081——91381.**

No.	0	1	2	3	4	5	6	7	8	9
760	88081	88087	88093	88098	88104	88110	88116	88121	88127	88133
761	88138	88144	88150	88156	88161	88167	88173	88178	88184	88190
762	88195	88201	88207	88213	88218	88224	88230	88235	88241	88247
763	88252	88258	88264	88270	88275	88281	88287	88292	88298	88304
764	88309	88315	88321	88326	88332	88338	88343	88349	88355	88360
765	88366	88372	88377	88383	88389	88395	88400	88406	88412	88417
766	88423	88429	88434	88440	88446	88451	88457	88463	88468	88474
767	88480	88485	88491	88497	88502	88508	88513	88519	88525	88530
768	88536	88542	88547	88553	88559	88564	88570	88576	88581	88587
769	88593	88598	88604	88610	88615	88621	88627	88632	88638	88643
770	88649	88655	88660	88666	88672	88677	88683	88689	88694	88700
771	88705	88711	88717	88722	88728	88734	88739	88745	88750	88756
772	88762	88767	88773	88779	88784	88790	88795	88801	88807	88812
773	88818	88824	88829	88835	88840	88846	88852	88857	88863	88868
774	88874	88880	88885	88891	88897	88902	88908	88913	88919	88925
775	88930	88936	88941	88947	88953	88958	88964	88969	88975	88981
776	88986	88992	88997	89003	89009	89014	89020	89025	89031	89037
777	89042	89048	89053	89059	89064	89070	89076	89081	89087	89092
778	89098	89104	89109	89115	89120	89126	89131	89137	89143	89148
779	89154	89159	89165	89170	89176	89182	89187	89193	89198	89204
780	89209	89215	89221	89226	89232	89237	89243	89248	89254	89260
781	89265	89271	89276	89282	89287	89293	89298	89304	89310	89315
782	89321	89326	89332	89337	89343	89348	89354	89360	89365	89371
783	89376	89382	89387	89393	89398	89404	89409	89415	89421	89426
784	89432	89437	89443	89448	89454	89459	89465	89470	89476	89481
785	89487	89492	89498	89504	89509	89515	89520	89526	89531	89537
786	89542	89548	89553	89559	89564	89570	89575	89581	89586	89592
787	89597	89603	89609	89614	89620	89625	89631	89636	89642	89647
788	89653	89658	89664	89669	89675	89680	89686	89691	89697	89702
789	89708	89713	89719	89724	89730	89735	89741	89746	89752	89757
790	89763	89768	89774	89779	89785	89790	89796	89801	89807	89812
791	89818	89823	89829	89834	89840	89845	89851	89856	89862	89867
792	89873	89878	89883	89889	89894	89900	89905	89911	89916	89922
793	89927	89933	89938	89944	89949	89955	89960	89966	89971	89977
794	89982	89988	89993	89998	90004	90009	90015	90020	90026	90031
795	90037	90042	90048	90053	90059	90064	90069	90075	90080	90086
796	90091	90097	90102	90108	90113	90119	90124	90129	90135	90140
797	90146	90151	90157	90162	90168	90173	90179	90184	90189	90195
798	90200	90206	90211	90217	90222	90227	90233	90238	90244	90249
799	90255	90260	90266	90271	90276	90282	90287	90293	90298	90304
800	90309	90314	90320	90325	90331	90336	90342	90347	90352	90358
801	90363	90369	90374	90380	90385	90390	90396	90401	90407	90412
802	90417	90423	90428	90434	90439	90445	90450	90455	90461	90466
803	90472	90477	90482	90488	90493	90499	90504	90509	90515	90520
804	90526	90531	90536	90542	90547	90553	90558	90563	90569	90574
805	90580	90585	90590	90596	90601	90607	90612	90617	90623	90628
806	90634	90639	90644	90650	90655	90660	90666	90671	90677	90682
807	90687	90693	90698	90703	90709	90714	90720	90725	90730	90736
808	90741	90747	90752	90757	90763	90768	90773	90779	90784	90789
809	90795	90800	90806	90811	90816	90822	90827	90832	90838	90843
810	90849	90854	90859	90865	90870	90875	90881	90886	90891	90897
811	90902	90907	90913	90918	90924	90929	90934	90940	90945	90950
812	90956	90961	90966	90972	90977	90982	90988	90993	90998	91004
813	91009	91014	91020	91025	91030	91036	91041	91046	91052	91057
814	91062	91068	91073	91078	91084	91089	91094	91100	91105	91110
815	91116	91121	91126	91132	91137	91142	91148	91153	91158	91164
816	91169	91174	91180	91185	91190	91196	91201	91206	91212	91217
817	91222	91228	91233	91238	91243	91249	91254	91259	91265	91270
818	91275	91281	91286	91291	91297	91302	91307	91312	91318	91323
819	91328	91334	91339	91344	91350	91355	91360	91365	91371	91376
No.	0	1	2	3	4	5	6	7	8	9

6	
1	1
2	1
3	2
4	2
5	3
6	4
7	4
8	5
9	5

5	
1	1
2	1
3	2
4	2
5	3
6	3
7	4
8	4
9	5

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 8200——8800. Log. 91381——94448.

No.	0	1	2	3	4	5	6	7	8	9
820	91381	91387	91392	91397	91403	91408	91413	91418	91424	91429
821	91434	91440	91445	91450	91455	91461	91466	91471	91477	91482
822	91487	91492	91498	91503	91508	91514	91519	91524	91529	91535
823	91540	91545	91551	91556	91561	91566	91572	91577	91582	91587
824	91593	91598	91603	91609	91614	91619	91624	91630	91635	91640
825	91645	91651	91656	91661	91666	91672	91677	91682	91687	91693
826	91698	91703	91709	91714	91719	91724	91730	91735	91740	91745
827	91751	91756	91761	91766	91772	91777	91782	91787	91793	91798
828	91803	91808	91814	91819	91824	91829	91834	91840	91845	91850
829	91855	91861	91866	91871	91876	91882	91887	91892	91897	91903
830	91908	91913	91918	91924	91929	91934	91939	91944	91950	91955
831	91960	91965	91971	91976	91981	91986	91991	91997	92002	92007
832	92012	92018	92023	92028	92033	92038	92044	92049	92054	92059
833	92065	92070	92075	92080	92085	92091	92096	92101	92106	92111
834	92117	92122	92127	92132	92137	92143	92148	92153	92158	92163
835	92169	92174	92179	92184	92189	92195	92200	92205	92210	92215
836	92221	92226	92231	92236	92241	92247	92252	92257	92262	92267
837	92273	92278	92283	92288	92293	92298	92304	92309	92314	92319
838	92324	92330	92335	92340	92345	92350	92355	92361	92366	92371
839	92376	92381	92387	92392	92397	92402	92407	92412	92418	92423
840	92428	92433	92438	92443	92449	92454	92459	92464	92469	92474
841	92480	92485	92490	92495	92500	92505	92511	92516	92521	92526
842	92531	92536	92542	92547	92552	92557	92562	92567	92572	92578
843	92583	92588	92593	92598	92603	92609	92614	92619	92624	92629
844	92634	92639	92645	92650	92655	92660	92665	92670	92675	92681
845	92686	92691	92696	92701	92706	92711	92716	92722	92727	92732
846	92737	92742	92747	92752	92758	92763	92768	92773	92778	92783
847	92788	92793	92799	92804	92809	92814	92819	92824	92829	92834
848	92840	92845	92850	92855	92860	92865	92870	92875	92881	92886
849	92891	92896	92901	92906	92911	92916	92921	92927	92932	92937
850	92942	92947	92952	92957	92962	92967	92973	92978	92983	92988
851	92993	92998	93003	93008	93013	93018	93024	93029	93034	93039
852	93044	93049	93054	93059	93064	93069	93075	93080	93085	93090
853	93095	93100	93105	93110	93115	93120	93125	93131	93136	93141
854	93146	93151	93156	93161	93166	93171	93176	93181	93186	93192
855	93197	93202	93207	93212	93217	93222	93227	93232	93237	93242
856	93247	93252	93258	93263	93268	93273	93278	93283	93288	93293
857	93298	93303	93308	93313	93318	93323	93328	93334	93339	93344
858	93349	93354	93359	93364	93369	93374	93379	93384	93389	93394
859	93399	93404	93409	93414	93420	93425	93430	93435	93440	93445
860	93450	93455	93460	93465	93470	93475	93480	93485	93490	93495
861	93500	93505	93510	93515	93520	93526	93531	93536	93541	93546
862	93551	93556	93561	93566	93571	93576	93581	93586	93591	93596
863	93601	93606	93611	93616	93621	93626	93631	93636	93641	93646
864	93651	93656	93661	93666	93671	93676	93682	93687	93692	93697
865	93702	93707	93712	93717	93722	93727	93732	93737	93742	93747
866	93752	93757	93762	93767	93772	93777	93782	93787	93792	93797
867	93802	93807	93812	93817	93822	93827	93832	93837	93842	93847
868	93852	93857	93862	93867	93872	93877	93882	93887	93892	93897
869	93902	93907	93912	93917	93922	93927	93932	93937	93942	93947
870	93952	93957	93962	93967	93972	93977	93982	93987	93992	93997
871	94002	94007	94012	94017	94022	94027	94032	94037	94042	94047
872	94052	94057	94062	94067	94072	94077	94082	94086	94091	94096
873	94101	94106	94111	94116	94121	94126	94131	94136	94141	94146
874	94151	94156	94161	94166	94171	94176	94181	94186	94191	94196
875	94201	94206	94211	94216	94221	94226	94231	94236	94240	94245
876	94250	94255	94260	94265	94270	94275	94280	94285	94290	94295
877	94300	94305	94310	94315	94320	94325	94330	94335	94340	94345
878	94349	94354	94359	94364	94369	94374	94379	94384	94389	94394
879	94399	94404	94409	94414	94419	94424	94429	94433	94438	94443
No.	0	1	2	3	4	5	6	7	8	9

6	
1	1
2	1
3	2
4	2
5	3
6	4
7	4
8	5
9	5

5	
1	1
2	1
3	2
4	2
5	3
6	3
7	4
8	4
9	5

4	
1	0
2	1
3	1
4	2
5	2
6	2
7	3
8	3
9	4

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 8800——9400. Log. 94448——97313.

No.	0	1	2	3	4	5	6	7	8	9
880	94448	94453	94458	94463	94468	94473	94478	94483	94488	94493
881	94498	94503	94507	94512	94517	94522	94527	94532	94537	94542
882	94547	94552	94557	94562	94567	94571	94576	94581	94586	94591
883	94596	94601	94606	94611	94616	94621	94626	94630	94635	94640
884	94645	94650	94655	94660	94665	94670	94675	94680	94685	94689
885	94694	94699	94704	94709	94714	94719	94724	94729	94734	94738
886	94743	94748	94753	94758	94763	94768	94773	94778	94783	94787
887	94792	94797	94802	94807	94812	94817	94822	94827	94832	94836
888	94841	94846	94851	94856	94861	94866	94871	94876	94880	94885
889	94890	94895	94900	94905	94910	94915	94919	94924	94929	94934
890	94939	94944	94949	94954	94959	94963	94968	94973	94978	94983
891	94988	94993	94998	95002	95007	95012	95017	95022	95027	95032
892	95036	95041	95046	95051	95056	95061	95066	95071	95075	95080
893	95085	95090	95095	95100	95105	95109	95114	95119	95124	95129
894	95134	95139	95143	95148	95153	95158	95163	95168	95173	95177
895	95182	95187	95192	95197	95202	95207	95211	95216	95221	95226
896	95231	95236	95240	95245	95250	95255	95260	95265	95270	95274
897	95279	95284	95289	95294	95299	95303	95308	95313	95318	95323
898	95328	95332	95337	95342	95347	95352	95357	95361	95366	95371
899	95376	95381	95386	95390	95395	95400	95405	95410	95415	95419
900	95424	95429	95434	95439	95444	95448	95453	95458	95463	95468
901	95472	95477	95482	95487	95492	95497	95501	95506	95511	95516
902	95521	95525	95530	95535	95540	95545	95550	95554	95559	95564
903	95569	95574	95578	95583	95588	95593	95598	95602	95607	95612
904	95617	95622	95626	95631	95636	95641	95646	95650	95655	95660
905	95665	95670	95674	95679	95684	95689	95694	95698	95703	95708
906	95713	95718	95722	95727	95732	95737	95742	95746	95751	95756
907	95761	95766	95770	95775	95780	95785	95789	95794	95799	95804
908	95809	95813	95818	95823	95828	95832	95837	95842	95847	95852
909	95856	95861	95866	95871	95875	95880	95885	95890	95895	95899
910	95904	95909	95914	95918	95923	95928	95933	95938	95942	95947
911	95952	95957	95961	95966	95971	95976	95980	95985	95990	95995
912	95999	96004	96009	96014	96019	96023	96028	96033	96038	96042
913	96047	96052	96057	96061	96066	96071	96076	96080	96085	96090
914	96095	96099	96104	96109	96114	96118	96123	96128	96133	96137
915	96142	96147	96152	96156	96161	96166	96171	96175	96180	96185
916	96190	96194	96199	96204	96209	96213	96218	96223	96227	96232
917	96237	96242	96246	96251	96256	96261	96265	96270	96275	96280
918	96284	96289	96294	96298	96303	96308	96313	96317	96322	96327
919	96332	96336	96341	96346	96350	96355	96360	96365	96369	96374
920	96379	96384	96388	96393	96398	96402	96407	96412	96417	96421
921	96426	96431	96435	96440	96445	96450	96454	96459	96464	96468
922	96473	96478	96483	96487	96492	96497	96501	96506	96511	96515
923	96520	96525	96530	96534	96539	96544	96548	96553	96558	96562
924	96567	96572	96577	96581	96586	96591	96595	96600	96605	96609
925	96614	96619	96624	96628	96633	96638	96642	96647	96652	96656
926	96661	96666	96670	96675	96680	96685	96689	96694	96699	96703
927	96708	96713	96717	96722	96727	96731	96736	96741	96745	96750
928	96755	96759	96764	96769	96774	96778	96783	96788	96792	96797
929	96802	96806	96811	96816	96820	96825	96830	96834	96839	96844
930	96848	96853	96858	96862	96867	96872	96876	96881	96886	96890
931	96895	96900	96904	96909	96914	96918	96923	96928	96932	96937
932	96942	96946	96951	96956	96960	96965	96970	96974	96979	96984
933	96988	96993	96997	97002	97007	97011	97016	97021	97025	97030
934	97035	97039	97044	97049	97053	97058	97063	97067	97072	97077
935	97081	97086	97090	97095	97100	97104	97109	97114	97118	97123
936	97128	97132	97137	97142	97146	97151	97155	97160	97165	97169
937	97174	97179	97183	97188	97192	97197	97202	97206	97211	97216
938	97220	97225	97230	97234	97239	97243	97248	97253	97257	97262
939	97267	97271	97276	97280	97285	97290	97294	97299	97304	97308
No.	0	1	2	3	4	5	6	7	8	9

5	
1	1
2	1
3	2
4	2
5	3
6	3
7	4
8	4
9	5

4	
1	0
2	1
3	1
4	2
5	2
6	2
7	3
8	3
9	4

Digitized by Google

TABLE XXVI.

Logarithms of Numbers.

No. 9400——10000. Log. 97313——99996.

No.	0	1	2	3	4	5	6	7	8	9
940	97313	97317	97322	97327	97331	97336	97340	97345	97350	97354
941	97359	97364	97368	97373	97377	97382	97387	97391	97396	97400
942	97405	97410	97414	97419	97424	97428	97433	97437	97442	97447
943	97451	97456	97460	97465	97470	97474	97479	97483	97488	97493
944	97497	97502	97506	97511	97516	97520	97525	97529	97534	97539
945	97543	97548	97552	97557	97562	97566	97571	97575	97580	97585
946	97589	97594	97598	97603	97607	97612	97617	97621	97626	97630
947	97635	97640	97644	97649	97653	97658	97663	97667	97672	97676
948	97681	97685	97690	97695	97699	97704	97708	97713	97717	97722
949	97727	97731	97736	97740	97745	97749	97754	97759	97763	97768
950	97772	97777	97782	97786	97791	97795	97800	97804	97809	97813
951	97818	97823	97827	97832	97836	97841	97845	97850	97855	97859
952	97864	97868	97873	97877	97882	97886	97891	97896	97900	97905
953	97909	97914	97918	97923	97928	97932	97937	97941	97946	97950
954	97955	97959	97964	97968	97973	97978	97982	97987	97991	97996
955	98000	98005	98009	98014	98019	98023	98028	98032	98037	98041
956	98046	98050	98055	98059	98064	98068	98073	98078	98082	98087
957	98091	98096	98100	98105	98109	98114	98118	98123	98127	98132
958	98137	98141	98146	98150	98155	98159	98164	98168	98173	98177
959	98182	98186	98191	98195	98200	98204	98209	98214	98218	98223
960	98227	98232	98236	98241	98245	98250	98254	98259	98263	98268
961	98272	98277	98281	98286	98290	98295	98299	98304	98308	98313
962	98318	98322	98327	98331	98336	98340	98345	98349	98354	98358
963	98363	98367	98372	98376	98381	98385	98390	98394	98399	98403
964	98408	98412	98417	98421	98426	98430	98435	98439	98444	98448
965	98453	98457	98462	98466	98471	98475	98480	98484	98489	98493
966	98498	98502	98507	98511	98516	98520	98525	98529	98534	98538
967	98543	98547	98552	98556	98561	98565	98570	98574	98579	98583
968	98588	98592	98597	98601	98605	98610	98614	98619	98623	98628
969	98632	98637	98641	98646	98650	98655	98659	98664	98668	98673
970	98677	98682	98686	98691	98695	98700	98704	98709	98713	98717
971	98722	98726	98731	98735	98740	98744	98749	98753	98758	98762
972	98767	98771	98776	98780	98784	98789	98793	98798	98802	98807
973	98811	98816	98820	98825	98829	98834	98838	98843	98847	98851
974	98856	98860	98865	98869	98874	98878	98883	98887	98892	98896
975	98900	98905	98909	98914	98918	98923	98927	98932	98936	98941
976	98945	98949	98954	98958	98963	98967	98972	98976	98981	98985
977	98989	98994	98998	99003	99007	99012	99016	99021	99025	99029
978	99034	99038	99043	99047	99052	99056	99061	99065	99069	99074
979	99078	99083	99087	99092	99096	99100	99105	99109	99114	99118
980	99123	99127	99131	99136	99140	99145	99149	99154	99158	99162
981	99167	99171	99176	99180	99185	99189	99193	99198	99202	99207
982	99211	99216	99220	99224	99229	99233	99238	99242	99247	99251
983	99255	99260	99264	99269	99273	99277	99282	99286	99291	99295
984	99300	99304	99308	99313	99317	99322	99326	99330	99335	99339
985	99344	99348	99352	99357	99361	99366	99370	99374	99379	99383
986	99388	99392	99396	99401	99405	99410	99414	99419	99423	99427
987	99432	99436	99441	99445	99449	99454	99458	99463	99467	99471
988	99476	99480	99484	99489	99493	99498	99502	99506	99511	99515
989	99520	99524	99528	99533	99537	99542	99546	99550	99555	99559
990	99564	99568	99572	99577	99581	99585	99590	99594	99599	99603
991	99607	99612	99616	99621	99625	99629	99634	99638	99642	99647
992	99651	99656	99660	99664	99669	99673	99677	99682	99686	99691
993	99695	99699	99704	99708	99712	99717	99721	99726	99730	99734
994	99739	99743	99747	99752	99756	99760	99765	99769	99774	99778
995	99782	99787	99791	99795	99800	99804	99808	99813	99817	99822
996	99826	99830	99835	99839	99843	99848	99852	99856	99861	99865
997	99870	99874	99878	99883	99887	99891	99896	99900	99904	99909
998	99913	99917	99922	99926	99930	99935	99939	99944	99948	99952
999	99957	99961	99965	99970	99974	99978	99983	99987	99991	99996
No.	0	1	2	3	4	5	6	7	8	9

5	
1	1
2	1
3	2
4	2
5	3
6	3
7	4
8	4
9	5

4	
1	0
2	1
3	1
4	2
5	2
6	2
7	3
8	3
9	4

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

0° 179°

M	Hour A.M.	Hour P.M.	Sine.	Diff. 1'	Cosecant.	Tangent.	Diff. 1'	Cotangent.	Secant.	Cosine.	M
0	12 0 0	0 0 0	Inf. Neg.		Infinite.	Inf. Neg.		Infinite.	10.00000	10.00000	60
1	11 59 52	0 8	6.46373	30103	13.53627	6.46373	30103	13.53627	00000	00000	59
2	59 44	0 16	76476	17609	23524	76476	17609	23524	00000	00000	58
3	59 36	0 24	94085	12494	05915	94085	12494	05915	00000	00000	57
4	59 28	0 32	7.06579	9691	12.93421	7.06579	9691	12.93421	00000	00000	56
5	11 59 20	0 0 40	7.16270	7918	12.83730	7.16270	7918	12.83730	10.00000	10.00000	55
6	59 12	0 48	24188	6694	75812	24188	6694	75812	00000	00000	54
7	59 4	0 56	30882	5800	69118	30882	5800	69118	00000	00000	53
8	58 56	1 4	36682	5115	63318	36682	5115	63318	00000	00000	52
9	58 48	1 12	41797	4576	58203	41797	4576	58203	00000	00000	51
10	11 58 40	0 1 20	7.46373	4139	12.53627	7.46373	4139	12.53627	10.00000	10.00000	50
11	58 32	1 28	50512	3779	49488	50512	3779	49488	00000	00000	49
12	58 24	1 36	54291	3476	45709	54291	3476	45709	00000	00000	48
13	58 16	1 44	57767	3218	42233	57767	3219	42233	00000	00000	47
14	58 8	1 52	60985	2997	39015	60986	2996	39014	00000	00000	46
15	11 58 0	0 2 0	7.63982	2802	12.36018	7.63982	2803	12.36018	10.00000	10.00000	45
16	57 52	2 8	66784	2633	33216	66785	2633	33215	00000	00000	44
17	57 44	2 16	69417	2483	30583	69418	2482	30582	00001	9.99999	43
18	57 36	2 24	71900	2348	28100	71900	2348	28100	00001	99999	42
19	57 28	2 32	74248	2227	25752	74248	2228	25752	00001	99999	41
20	11 57 20	0 2 40	7.76475	2119	12.23525	7.76476	2119	12.23524	10.00001	9.99999	40
21	57 12	2 48	78594	2021	21406	78595	2020	21405	00001	99999	39
22	57 4	2 56	80615	1930	19385	80615	1931	19385	00001	99999	38
23	56 56	3 4	82545	1848	17455	82546	1848	17454	00001	99999	37
24	56 48	3 12	84393	1773	15607	84394	1773	15606	00001	99999	36
25	11 56 40	0 3 20	7.86166	1704	12.13834	7.86167	1704	12.13833	10.00001	9.99999	35
26	56 32	3 28	87870	1639	12130	87871	1639	12129	00001	99999	34
27	56 24	3 36	89509	1579	10491	89510	1579	10490	00001	99999	33
28	56 16	3 44	91088	1524	08912	91089	1524	08911	00001	99999	32
29	56 8	3 52	92612	1472	07388	92613	1473	07387	00002	99998	31
30	11 56 0	0 4 0	7.94084	1424	12.05916	7.94086	1424	12.05914	10.00002	9.99998	30
31	55 52	4 8	95508	1379	04492	95510	1379	04490	00002	99998	29
32	55 44	4 16	96887	1336	03113	96889	1336	03111	00002	99998	28
33	55 36	4 24	98223	1297	01777	98225	1297	01775	00002	99998	27
34	55 28	4 32	99520	1259	00480	99522	1259	00478	00002	99998	26
35	11 55 20	0 4 40	8.00779	1223	11.99221	8.00781	1223	11.99219	10.00002	9.99998	25
36	55 12	4 48	02002	1190	97998	02004	1190	97996	00002	99998	24
37	55 4	4 56	03192	1158	96808	03194	1159	96806	00003	99997	23
38	54 56	5 4	04350	1128	95650	04353	1128	95647	00003	99997	22
39	54 48	5 12	05478	1100	94522	05481	1100	94519	00003	99997	21
40	11 54 40	0 5 20	8.06578	1072	11.93422	8.06581	1072	11.93419	10.00003	9.99997	20
41	54 32	5 28	07650	1046	92350	07653	1047	92347	00003	99997	19
42	54 24	5 36	08696	1022	91304	08700	1022	91300	00003	99997	18
43	54 16	5 44	09718	999	90282	09722	998	90278	00003	99997	17
44	54 8	5 52	10717	976	89283	10720	976	89280	00004	99996	16
45	11 54 0	0 6 0	8.11693	954	11.88307	8.11696	955	11.88304	10.00004	9.99996	15
46	53 52	6 8	12647	934	87353	12651	934	87349	00004	99996	14
47	53 44	6 16	13581	914	86419	13585	915	86415	00004	99996	13
48	53 36	6 24	14495	896	85505	14500	895	85500	00004	99996	12
49	53 28	6 32	15391	877	84609	15395	878	84605	00004	99996	11
50	11 53 20	0 6 40	8.16268	860	11.83732	8.16273	860	11.83727	10.00005	9.99995	10
51	53 12	6 48	17128	843	82872	17133	843	82867	00005	99995	9
52	53 4	6 56	17971	827	82029	17976	828	82024	00005	99995	8
53	52 56	7 4	18798	812	81202	18804	812	81196	00005	99995	7
54	52 48	7 12	19610	797	80390	19616	797	80384	00005	99995	6
55	11 52 40	0 7 20	8.20407	782	11.79593	8.20413	782	11.79587	10.00006	9.99994	5
56	52 32	7 28	21189	769	78811	21195	769	78805	00006	99994	4
57	52 24	7 36	21958	755	78042	21964	756	78036	00006	99994	3
58	52 16	7 44	22713	743	77287	22720	742	77280	00006	99994	2
59	52 8	7 52	23456	730	76544	23462	730	76538	00006	99994	1
60	52 0	8 0	24186	717	75814	24192	718	75808	00007	99993	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff. 1'	Secant	Cotangent	Diff. 1'	Tangent.	Cosecant.	Sine.	M

90° 89°

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

1° | 178°

M	Hour A.M.	Hour P.M.	Sine.	Diff. 1'	Cosecant.	Tangent.	Diff. 1'	Cotangent	Secant.	Cosine.	M
0	11 52 0	0 8 0	8.24186	717	11.75814	8.24192	718	11.75808	10.00007	9.99993	60
1	51 52	8 8	24903	706	75097	24910	706	75090	00007	99993	59
2	51 44	8 16	25609	695	74391	25616	696	74384	00007	99993	58
3	51 36	8 24	26304	684	73696	26312	684	73688	00007	99993	57
4	51 28	8 32	26988	673	73012	26996	673	73004	00008	99992	56
5	11 51 20	0 8 40	8.27661	663	11.72339	8.27669	663	11.72331	10.00008	9.99992	55
6	51 12	8 48	28324	653	71676	28332	654	71668	00008	99992	54
7	51 4	8 56	28977	644	71023	28986	643	71014	00008	99992	53
8	50 56	9 4	29621	634	70379	29629	634	70371	00008	99992	52
9	50 48	9 12	30255	624	69745	30263	625	69737	00009	99991	51
10	11 50 40	0 9 20	8.30879	616	11.69121	8.30888	617	11.69112	10.00009	9.99991	50
11	50 32	9 28	31495	608	68505	31505	607	68495	00009	99991	49
12	50 24	9 36	32103	599	67897	32112	599	67888	00010	99990	48
13	50 16	9 44	32702	590	67298	32711	591	67289	00010	99990	47
14	50 8	9 52	33292	583	66708	33302	584	66698	00010	99990	46
15	11 50 0	0 10 0	8.33875	575	11.66125	8.33886	575	11.66114	10.00010	9.99990	45
16	49 52	10 8	34450	568	65550	34461	568	65539	00011	99989	44
17	49 44	10 16	35018	560	64982	35029	561	64971	00011	99989	43
18	49 36	10 24	35578	553	64422	35590	553	64410	00011	99989	42
19	49 28	10 32	36131	547	63869	36143	546	63857	00011	99989	41
20	11 49 20	0 10 40	8.36678	539	11.63322	8.36689	540	11.63311	10.00012	9.99988	40
21	49 12	10 48	37217	533	62783	37229	533	62771	00012	99988	39
22	49 4	10 56	37750	526	62250	37762	527	62238	00012	99988	38
23	48 56	11 4	38276	520	61724	38289	520	61711	00013	99987	37
24	48 48	11 12	38796	514	61204	38809	514	61191	00013	99987	36
25	11 48 40	0 11 20	8.39310	508	11.60690	8.39323	509	11.60677	10.00013	9.99987	35
26	48 32	11 28	39818	502	60182	39832	502	60168	00014	99986	34
27	48 24	11 36	40320	496	59680	40334	496	59666	00014	99986	33
28	48 16	11 44	40816	491	59184	40830	491	59170	00014	99986	32
29	48 8	11 52	41307	485	58693	41321	486	58679	00015	99985	31
30	11 48 0	0 12 0	8.41792	480	11.58208	8.41807	480	11.58193	10.00015	9.99985	30
31	47 52	12 8	42272	474	57728	42287	475	57713	00015	99985	29
32	47 44	12 16	42746	470	57254	42762	470	57238	00016	99984	28
33	47 36	12 24	43216	464	56784	43232	464	56768	00016	99984	27
34	47 28	12 32	43680	459	56320	43696	460	56304	00016	99984	26
35	11 47 20	0 12 40	8.44139	455	11.55861	8.44156	455	11.55844	10.00017	9.99983	25
36	47 12	12 48	44594	450	55406	44611	450	55389	00017	99983	24
37	47 4	12 56	45044	445	54956	45061	446	54939	00017	99983	23
38	46 56	13 4	45489	441	54511	45507	441	54493	00018	99982	22
39	46 48	13 12	45930	436	54070	45948	437	54052	00018	99982	21
40	11 46 40	0 13 20	8.46366	433	11.53634	8.46385	432	11.53615	10.00018	9.99982	20
41	46 32	13 28	46799	427	53201	46817	428	53183	00019	99981	19
42	46 24	13 36	47226	424	52774	47245	424	52755	00019	99981	18
43	46 16	13 44	47650	419	52350	47669	420	52331	00019	99981	17
44	46 8	13 52	48069	416	51931	48089	416	51911	00020	99980	16
45	11 46 0	0 14 0	8.48485	411	11.51515	8.48505	412	11.51495	10.00020	9.99980	15
46	45 52	14 8	48896	408	51104	48917	408	51083	00021	99979	14
47	45 44	14 16	49304	404	50696	49325	404	50675	00021	99979	13
48	45 36	14 24	49708	400	50292	49729	401	50271	00021	99979	12
49	45 28	14 32	50108	396	49892	50130	397	49870	00022	99978	11
50	11 45 20	0 14 40	8.50504	393	11.49496	8.50527	393	11.49473	10.00022	9.99978	10
51	45 12	14 48	50897	390	49103	50920	390	49080	00023	99977	9
52	45 4	14 56	51287	386	48713	51310	386	48690	00023	99977	8
53	44 56	15 4	51673	382	48327	51696	383	48304	00023	99977	7
54	44 48	15 12	52055	379	47945	52079	380	47921	00024	99976	6
55	11 44 40	0 15 20	8.52434	376	11.47566	8.52459	376	11.47541	10.00024	9.99976	5
56	44 32	15 28	52810	373	47190	52835	373	47165	00025	99975	4
57	44 24	15 36	53183	369	46817	53208	370	46792	00025	99975	3
58	44 16	15 44	53552	367	46448	53578	367	46422	00026	99974	2
59	44 8	15 52	53919	363	46081	53945	363	46055	00026	99974	1
60	44 0	16 0	54282	360	45718	54308	361	45692	00026	99974	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff. 1'	Secant.	Cotangent	Diff. 1'	Tangent.	Cosecant.	Sine.	M

91° | 88°

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

2° 177°

M	Hour A.M.	Hour P.M.	Sine.	Diff. 1'	Cosecant.	Tangent.	Diff. 1'	Cotangent.	Secant.	Cosine.	M
0	11 44 0	0 16 0	8.54282	360	11.45718	8.54308	361	11.45692	10.00026	9.99974	60
1	43 52	16 8	54642	357	45358	54669	358	45331	00027	99973	59
2	43 44	16 16	54999	355	45001	55027	355	44973	00027	99973	58
3	43 36	16 24	55354	351	44646	55382	352	44618	00028	99972	57
4	43 28	16 32	55705	349	44295	55734	349	44266	00028	99972	56
5	11 43 20	0 16 40	8.56054	346	11.43946	8.56083	346	11.43917	10.00029	9.99971	55
6	43 12	16 48	56400	343	43600	56429	344	43571	00029	99971	54
7	43 4	16 56	56743	341	43257	56773	341	43227	00030	99970	53
8	42 56	17 4	57084	337	42916	57114	338	42886	00030	99970	52
9	42 48	17 12	57421	336	42579	57452	336	42548	00031	99969	51
10	11 42 40	0 17 20	8.57757	332	11.42243	8.57788	333	11.42212	10.00031	9.99969	50
11	42 32	17 28	58089	330	41911	58121	330	41879	00032	99968	49
12	42 24	17 36	58419	328	41581	58451	328	41549	00032	99968	48
13	42 16	17 44	58747	325	41253	58779	326	41221	00033	99967	47
14	42 8	17 52	59072	323	40928	59105	323	40895	00033	99967	46
15	11 42 0	0 18 0	8.59395	320	11.40605	8.59428	321	11.40572	10.00033	9.99967	45
16	41 52	18 8	59715	318	40285	59749	319	40251	00034	99966	44
17	41 44	18 16	60033	316	39967	60068	316	39932	00034	99966	43
18	41 36	18 24	60349	313	39651	60384	314	39616	00035	99965	42
19	41 28	18 32	60662	311	39338	60698	311	39302	00036	99964	41
20	11 41 20	0 18 40	8.60973	309	11.39027	8.61009	310	11.38991	10.00036	9.99964	40
21	41 12	18 48	61282	307	38718	61319	307	38681	00037	99963	39
22	41 4	18 56	61589	305	38411	61626	305	38374	00037	99963	38
23	40 56	19 4	61894	302	38106	61931	303	38069	00038	99962	37
24	40 48	19 12	62196	301	37804	62234	301	37766	00038	99962	36
25	11 40 40	0 19 20	8.62497	298	11.37503	8.62535	299	11.37465	10.00039	9.99961	35
26	40 32	19 28	62795	296	37205	62834	297	37166	00039	99961	34
27	40 24	19 36	63091	294	36909	63131	295	36869	00040	99960	33
28	40 16	19 44	63385	293	36615	63426	292	36574	00040	99960	32
29	40 8	19 52	63678	290	36322	63718	291	36282	00041	99959	31
30	11 40 0	0 20 0	8.63968	288	11.36032	8.64009	289	11.35991	10.00041	9.99959	30
31	39 52	20 8	64256	287	35744	64298	287	35702	00042	99958	29
32	39 44	20 16	64543	284	35457	64585	285	35415	00042	99958	28
33	39 36	20 24	64827	283	35173	64870	284	35130	00043	99957	27
34	39 28	20 32	65110	281	34890	65154	281	34846	00044	99956	26
35	11 39 20	0 20 40	8.65391	279	11.34609	8.65435	280	11.34565	10.00044	9.99956	25
36	39 12	20 48	65670	277	34330	65715	278	34285	00045	99955	24
37	39 4	20 56	65947	276	34053	65993	276	34007	00045	99955	23
38	38 56	21 4	66223	274	33777	66269	274	33731	00046	99954	22
39	38 48	21 12	66497	272	33503	66543	273	33457	00046	99954	21
40	11 38 40	0 21 20	8.66769	270	11.33231	8.66816	271	11.33184	10.00047	9.99953	20
41	38 32	21 28	67039	269	32961	67087	269	32913	00048	99952	19
42	38 24	21 36	67308	267	32692	67356	268	32644	00048	99952	18
43	38 16	21 44	67575	266	32425	67624	266	32376	00049	99951	17
44	38 8	21 52	67841	263	32159	67890	264	32110	00049	99951	16
45	11 38 0	0 22 0	8.68104	263	11.31896	8.68154	263	11.31846	10.00050	9.99950	15
46	37 52	22 8	68367	260	31633	68417	261	31583	00051	99949	14
47	37 44	22 16	68627	259	31373	68678	260	31322	00051	99949	13
48	37 36	22 24	68886	258	31114	68938	258	31062	00052	99948	12
49	37 28	22 32	69144	256	30856	69196	257	30804	00052	99948	11
50	11 37 20	0 22 40	8.69400	254	11.30600	8.69453	255	11.30547	10.00053	9.99947	10
51	37 12	22 48	69654	253	30346	69708	254	30292	00054	99946	9
52	37 4	22 56	69907	252	30093	69962	252	30038	00054	99946	8
53	36 56	23 4	70159	250	29841	70214	251	29786	00055	99945	7
54	36 48	23 12	70409	249	29591	70465	249	29535	00056	99944	6
55	11 36 40	0 23 20	8.70658	247	11.29342	8.70714	248	11.29286	10.00056	9.99944	5
56	36 32	23 28	70905	246	29095	70962	246	29038	00057	99943	4
57	36 24	23 36	71151	244	28849	71208	245	28792	00058	99942	3
58	36 16	23 44	71395	243	28605	71453	244	28547	00058	99942	2
59	36 8	23 52	71638	242	28362	71697	243	28303	00059	99941	1
60	36 0	24 0	71880	240	28120	71940	241	28060	00060	99940	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff. 1'	Secant.	Cotangent.	Diff. 1'	Tangent.	Cosecant.	Sine.	M

92° 87°

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

3° 176°

M	Hour A.M.	Hour P.M.	Sine.	Diff. 1'	Cosecant.	Tangent.	Diff. 1'	Cotangent	Secant.	Cosine.	M
0	11 36 0	0 24 0	8.71880	240	11.28120	8.71940	241	11.28060	10.00060	9.99940	60
1	35 52	24 8	72120	239	27880	72181	239	27819	00060	99940	59
2	35 44	24 16	72359	238	27641	72420	239	27580	00061	99939	58
3	35 36	24 24	72597	237	27403	72659	237	27341	00062	99938	57
4	35 28	24 32	72834	235	27166	72896	236	27104	00062	99938	56
5	11 35 20	0 24 40	8.73069	234	11.26931	8.73132	234	11.26868	10.00063	9.99937	55
6	35 12	24 48	73303	232	26697	73366	234	26634	00064	99936	54
7	35 4	24 56	73535	232	26465	73600	232	26400	00064	99936	53
8	34 56	25 4	73767	230	26233	73832	231	26168	00065	99935	52
9	34 48	25 12	73997	229	26003	74063	229	25937	00066	99934	51
10	11 34 40	0 25 20	8.74226	228	11.25774	8.74292	229	11.25708	10.00066	9.99934	50
11	34 32	25 28	74454	226	25546	74521	227	25479	00067	99933	49
12	34 24	25 36	74680	226	25320	74748	226	25252	00068	99932	48
13	34 16	25 44	74906	224	25094	74974	225	25026	00068	99932	47
14	34 8	25 52	75130	223	24870	75199	224	24801	00069	99931	46
15	11 34 0	0 26 0	8.75353	222	11.24647	8.75423	222	11.24577	10.00070	9.99930	45
16	33 52	26 8	75575	220	24425	75645	222	24355	00071	99929	44
17	33 44	26 16	75795	220	24205	75867	220	24133	00071	99929	43
18	33 36	26 24	76015	219	23985	76087	219	23913	00072	99928	42
19	33 28	26 32	76234	217	23766	76306	219	23694	00073	99927	41
20	11 33 20	0 26 40	8.76451	216	11.23549	8.76525	217	11.23475	10.00074	9.99926	40
21	33 12	26 48	76667	216	23333	76742	216	23258	00074	99926	39
22	33 4	26 56	76883	214	23117	76958	215	23042	00075	99925	38
23	32 56	27 4	77097	213	22903	77173	214	22827	00076	99924	37
24	32 48	27 12	77310	212	22690	77387	213	22613	00077	99923	36
25	11 32 40	0 27 20	8.77522	211	11.22478	8.77600	211	11.22400	10.00077	9.99923	35
26	32 32	27 28	77733	210	22267	77811	211	22189	00078	99922	34
27	32 24	27 36	77943	209	22057	78022	210	21978	00079	99921	33
28	32 16	27 44	78152	208	21848	78232	209	21768	00080	99920	32
29	32 8	27 52	78360	208	21640	78441	208	21559	00080	99920	31
30	11 32 0	0 28 0	8.78568	206	11.21432	8.78649	206	11.21351	10.00081	9.99919	30
31	31 52	28 8	78774	205	21226	78855	206	21145	00082	99918	29
32	31 44	28 16	78979	204	21021	79061	205	20939	00083	99917	28
33	31 36	28 24	79183	203	20817	79266	204	20734	00083	99917	27
34	31 28	28 32	79386	202	20614	79470	203	20530	00084	99916	26
35	11 31 20	0 28 40	8.79588	201	11.20412	8.79673	202	11.20327	10.00085	9.99915	25
36	31 12	28 48	79789	201	20211	79875	201	20125	00086	99914	24
37	31 4	28 56	79990	199	20010	80076	201	19924	00087	99913	23
38	30 56	29 4	80189	199	19811	80277	199	19723	00087	99913	22
39	30 48	29 12	80388	197	19612	80476	198	19524	00088	99912	21
40	11 30 40	0 29 20	8.80585	197	11.19415	8.80674	198	11.19326	10.00089	9.99911	20
41	30 32	29 28	80782	196	19218	80872	196	19128	00090	99910	19
42	30 24	29 36	80978	195	19022	81068	196	18932	00091	99909	18
43	30 16	29 44	81173	194	18827	81264	195	18736	00091	99909	17
44	30 8	29 52	81367	193	18633	81459	194	18541	00092	99908	16
45	11 30 0	0 30 0	8.81560	192	11.18440	8.81653	193	11.18347	10.00093	9.99907	15
46	29 52	30 8	81752	192	18248	81846	192	18154	00094	99906	14
47	29 44	30 16	81944	190	18056	82038	192	17962	00095	99905	13
48	29 36	30 24	82134	190	17866	82230	190	17770	00096	99904	12
49	29 28	30 32	82324	189	17676	82420	190	17580	00096	99904	11
50	11 29 20	0 30 40	8.82513	188	11.17487	8.82610	189	11.17390	10.00097	9.99903	10
51	29 12	30 48	82701	187	17299	82799	188	17201	00098	99902	9
52	29 4	30 56	82888	187	17112	82987	188	17013	00099	99901	8
53	28 56	31 4	83075	186	16925	83175	186	16825	00100	99900	7
54	28 48	31 12	83261	185	16739	83361	186	16639	00101	99899	6
55	11 28 40	0 31 20	8.83446	184	11.16554	8.83547	185	11.16453	10.00102	9.99898	5
56	28 32	31 28	83630	183	16370	83732	184	16268	00102	99898	4
57	28 24	31 36	83813	183	16187	83916	184	16084	00103	99897	3
58	28 16	31 44	83996	181	16004	84100	182	15900	00104	99896	2
59	28 8	31 52	84177	181	15823	84282	182	15718	00105	99895	1
60	28 0	32 0	84358	181	15642	84464	182	15536	00106	99894	0
M	Hour P.M.	Hour A.M.	Cosine	Diff. 1'	Secant.	Cotangent	Diff. 1'	Tangent.	Cosecant.	Sine.	M

93° 86°

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

4° 175°

M	Hour A.M.	Hour P.M.	Sine.	Diff. 1′	Cosecant.	Tangent.	Diff. 1′	Cotangent	Secant.	Cosine.	M
0	11 28 0	0 32 0	8.84358	181	11.15642	8.84464	182	11.15536	10.00106	9.99894	60
1	27 52	32 8	84539	179	15461	84646	180	15354	00107	99893	59
2	27 44	32 16	84718	179	15282	84826	180	15174	00108	99892	58
3	27 36	32 24	84897	178	15103	85006	179	14994	00109	99891	57
4	27 28	32 32	85075	177	14925	85185	178	14815	00109	99891	56
5	11 27 20	0 32 40	8.85252	177	11.14748	8.85363	177	11.14637	10.00110	9.99890	55
6	27 12	32 48	85429	176	14571	85540	177	14460	00111	99889	54
7	27 4	32 56	85605	175	14395	85717	176	14283	00112	99888	53
8	26 56	33 4	85780	175	14220	85893	176	14107	00113	99887	52
9	26 48	33 12	85955	173	14045	86069	174	13931	00114	99886	51
10	11 26 40	0 33 20	8.86128	173	11 13872	8.86243	174	11.13757	10.00115	9.99885	50
11	26 32	33 28	86301	173	13699	86417	174	13583	00116	99884	49
12	26 24	33 36	86474	171	13526	86591	172	13409	00117	99883	48
13	26 16	33 44	86645	171	13355	86763	172	13237	00118	99882	47
14	26 8	33 52	86816	171	13184	86935	171	13065	00119	99881	46
15	11 26 0	0 34 0	8.86987	169	11.13013	8.87106	171	11.12894	10.00120	9.99880	45
16	25 52	34 8	87156	169	12844	87277	170	12723	00121	99879	44
17	25 44	34 16	87325	169	12675	87447	169	12553	00121	99879	43
18	25 36	34 24	87494	167	12506	87616	169	12384	00122	99878	42
19	25 28	34 32	87661	168	12339	87785	168	12215	00123	99877	41
20	11 25 20	0 34 40	8.87829	166	11.12171	8.87953	167	11.12047	10.00124	9.99876	40
21	25 12	34 48	87995	166	12005	88120	167	11880	00125	99875	39
22	25 4	34 56	88161	165	11839	88287	166	11713	00126	99874	38
23	24 56	35 4	88326	164	11674	88453	165	11547	00127	99873	37
24	24 48	35 12	88490	164	11510	88618	165	11382	00128	99872	36
25	11 24 40	0 35 20	8.88654	163	11.11346	8.88783	165	11.11217	10.00129	9.99871	35
26	24 32	35 28	88817	163	11183	88948	163	11052	00130	99870	34
27	24 24	35 36	88980	162	11020	89111	163	10889	00131	99869	33
28	24 16	35 44	89142	162	10858	89274	163	10726	00132	99868	32
29	24 8	35 52	89304	160	10696	89437	161	10563	00133	99867	31
30	11 24 0	0 36 0	8.89464	161	11.10536	8.89598	162	11.10402	10.00134	9.99866	30
31	23 52	36 8	89625	159	10375	89760	160	10240	00135	99865	29
32	23 44	36 16	89784	159	10216	89920	160	10080	00136	99864	28
33	23 36	36 24	89943	159	10057	90080	160	09920	00137	99863	27
34	23 28	36 32	90102	158	09898	90240	159	09760	00138	99862	26
35	11 23 20	0 36 40	8.90260	157	11.09740	8.90399	158	11.09601	10.00139	9.99861	25
36	23 12	36 48	90417	157	09583	90557	158	09443	00140	99860	24
37	23 4	36 56	90574	156	09426	90715	157	09285	00141	99859	23
38	22 56	37 4	90730	155	09270	90872	157	09128	00142	99858	22
39	22 48	37 12	90885	155	09115	91029	156	08971	00143	99857	21
40	11 22 40	0 37 20	8.91040	155	11.08960	8.91185	155	11.08815	10.00144	9.99856	20
41	22 32	37 28	91195	154	08805	91340	155	08660	00145	99855	19
42	22 24	37 36	91349	153	08651	91495	155	08505	00146	99854	18
43	22 16	37 44	91502	153	08498	91650	153	08350	00147	99853	17
44	22 8	37 52	91655	152	08345	91803	154	08197	00148	99852	16
45	11 22 0	0 38 0	8.91807	152	11.08193	8.91957	153	11.08043	10.00149	9.99851	15
46	21 52	38 8	91959	151	08041	92110	152	07890	00150	99850	14
47	21 44	38 16	92110	151	07890	92262	152	07738	00152	99848	13
48	21 36	38 24	92261	150	07739	92414	151	07586	00153	99847	12
49	21 28	38 32	92411	150	07589	92565	151	07435	00154	99846	11
50	11 21 20	0 38 40	8.92561	149	11.07439	8.92716	150	11.07284	10.00155	9.99845	10
51	21 12	38 48	92710	149	07290	92866	150	07134	00156	99844	9
52	21 4	38 56	92859	148	07141	93016	149	06984	00157	99843	8
53	20 56	39 4	93007	147	06993	93165	148	06835	00158	99842	7
54	20 48	39 12	93154	147	06846	93313	149	06687	00159	99841	6
55	11 20 40	0 39 20	8.93301	147	11.06699	8.93462	147	11.06538	10.00160	9.99840	5
56	20 32	39 28	93448	146	06552	93609	147	06391	00161	99839	4
57	20 24	39 36	93594	146	06406	93756	147	06244	00162	99838	3
58	20 16	39 44	93740	145	06260	93903	146	06097	00163	99837	2
59	20 8	39 52	93885	145	06115	94049	146	05951	00164	99836	1
60	20 0	40 0	94030	144	05970	94195	145	05805	00166	99834	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff. 1′	Secant.	Cotangent	Diff. 1′	Tangent.	Cosecant.	Sine.	M

94° 85°

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

5° 174°

M	Hour A.M.	Hour P.M.	Sine. (A)	Diff.	Cosecant. (A)	Tangent. (B)	Diff.	Cotangent (B)	Secant. (C)	Diff.	Cosine. (C)	M
0	11 20 00	0 40 0	8.94030	0	11.05970	8.94195	0	11.05805	10.00166	0	9.99834	60
1	19 52	40 8	94174	2	05826	94340	2	05660	00167	0	99833	59
2	19 44	40 16	94317	4	05683	94485	4	05515	00168	0	99832	58
3	19 36	40 24	94461	7	05539	94630	7	05370	00169	0	99831	57
4	19 28	40 32	94603	9	05397	94773	9	05227	00170	0	99830	56
5	11 19 20	0 40 40	8.94746	11	11.05254	8.94917	11	11.05083	10.00171	0	9.99829	55
6	19 12	40 48	94887	13	05113	95060	13	04940	00172	0	99828	54
7	19 4	40 56	95029	15	04971	95202	15	04798	00173	0	99827	53
8	18 56	41 4	95170	18	04830	95344	18	04656	00175	0	99825	52
9	18 48	41 12	95310	20	04690	95486	20	04514	00176	0	99824	51
10	11 18 40	0 41 20	8.95450	22	11.04550	8.95627	22	11.04373	10.00177	0	9.99823	50
11	18 32	41 28	95589	24	04411	95767	24	04233	00178	0	99822	49
12	18 24	41 36	95728	26	04272	95908	27	04092	00179	0	99821	48
13	18 16	41 44	95867	29	04133	96047	29	03953	00180	0	99820	47
14	18 8	41 52	96005	31	03995	96187	31	03813	00181	0	99819	46
15	11 18 0	0 42 0	8.96143	33	11.03857	8.96325	33	11.03675	10.00183	0	9.99817	45
16	17 52	42 8	96280	35	03720	96464	35	03536	00184	0	99816	44
17	17 44	42 16	96417	37	03583	96602	38	03398	00185	0	99815	43
18	17 36	42 24	96553	39	03447	96739	40	03261	00186	0	99814	42
19	17 28	42 32	96689	42	03311	96877	42	03123	00187	0	99813	41
20	11 17 20	0 42 40	8.96825	44	11.03175	8.97013	44	11.02987	10.00188	0	9.99812	40
21	17 12	42 48	96960	46	03040	97150	46	02850	00190	0	99810	39
22	17 4	42 56	97095	48	02905	97285	49	02715	00191	0	99809	38
23	16 56	43 4	97229	50	02771	97421	51	02579	00192	0	99808	37
24	16 48	43 12	97363	53	02637	97556	53	02444	00193	0	99807	36
25	11 16 40	0 43 20	8.97496	55	11.02504	8.97691	55	11.02309	10.00194	1	9.99806	35
26	16 32	43 28	97629	57	02371	97825	58	02175	00196	1	99804	34
27	16 24	43 36	97762	59	02238	97959	60	02041	00197	1	99803	33
28	16 16	43 44	97894	61	02106	98092	62	01908	00198	1	99802	32
29	16 8	43 52	98026	64	01974	98225	64	01775	00199	1	99801	31
30	11 16 0	0 44 0	8.98157	66	11.01843	8.98358	66	11.01642	10.00200	1	9.99800	30
31	15 52	44 8	98288	68	01712	98490	69	01510	00202	1	99798	29
32	15 44	44 16	98419	70	01581	98622	71	01378	00203	1	99797	28
33	15 36	44 24	98549	72	01451	98753	73	01247	00204	1	99796	27
34	15 28	44 32	98679	75	01321	98884	75	01116	00205	1	99795	26
35	11 15 20	0 44 40	8.98808	77	11.01192	8.99015	77	11.00985	10.00207	1	9.99793	25
36	15 12	44 48	98937	79	01063	99145	80	00855	00208	1	99792	24
37	15 4	44 56	99066	81	00934	99275	82	00725	00209	1	99791	23
38	14 56	45 4	99194	83	00806	99405	84	00595	00210	1	99790	22
39	14 48	45 12	99322	86	00678	99534	86	00466	00212	1	99788	21
40	11 14 40	0 45 20	8.99450	88	11.00550	8.99662	89	11.00338	10.00213	1	9.99787	20
41	14 32	45 28	99577	90	00423	99791	91	00209	00214	1	99786	19
42	14 24	45 36	99704	92	00296	99919	93	00081	00215	1	99785	18
43	14 16	45 44	99830	94	00170	9.00046	95	10.99954	00217	1	99783	17
44	14 8	45 52	99956	96	00044	00174	97	99826	00218	1	99782	16
45	11 14 0	0 46 0	9.00082	99	10.99918	9.00301	100	10.99699	10.00219	1	9.99781	15
46	13 52	46 8	00207	101	99793	00427	102	99573	00220	1	99780	14
47	13 44	46 16	00332	103	99668	00553	104	99447	00222	1	99778	13
48	13 36	46 24	00456	105	99544	00679	106	99321	00223	1	99777	12
49	13 28	46 32	00581	107	99419	00805	108	99195	00224	1	99776	11
50	11 13 20	0 46 40	9.00704	110	10.99296	9.00930	111	10.99070	10.00225	1	9.99775	10
51	13 12	46 48	00828	112	99172	01055	113	98945	00227	1	99773	9
52	13 4	46 56	00951	114	99049	01179	115	98821	00228	1	99772	8
53	12 56	47 4	01074	116	98926	01303	117	98697	00229	1	99771	7
54	12 48	47 12	01196	118	98804	01427	120	98573	00231	1	99769	6
55	11 12 40	0 47 20	9.01318	121	10.98682	9.01550	122	10.98450	10.00232	1	9.99768	5
56	12 32	47 28	01440	123	98560	01673	124	98327	00233	1	99767	4
57	12 24	47 36	01561	125	98439	01796	126	98204	00235	1	99765	3
58	12 16	47 44	01682	127	98318	01918	128	98082	00236	1	99764	2
59	12 8	47 52	01803	129	98197	02040	131	97960	00237	1	99763	1
60	12 0	48 0	01923	132	98077	02162	133	97838	00239	1	99761	0
M	Hour P.M.	Hour A.M.	Cosine (A)	Diff.	Secant. (A)	Cotangent (B)	Diff.	Tangent. (B)	Cosecant. (C)	Diff.	Sine. (C)	M

95° 84°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	16	33	49	66	82	99	115
	B	17	33	50	66	83	100	116
	C	0	0	0	1	1	1	1

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

8

6°			A		A	B		B	C		C	173°
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine	M
0	11 12 0	0 48 0	9.01923	0	10.98077	9.02162	0	10.97838	10.00239	0	9.99761	60
1	11 52	48 8	02043	2	97957	02283	2	97717	00240	0	99760	59
2	11 44	48 16	02163	4	97837	02404	4	97596	00241	0	99759	58
3	11 36	48 24	02283	6	97717	02525	6	97475	00243	0	99757	57
4	11 28	48 32	02402	7	97598	02645	8	97355	00244	0	99756	56
5	11 11 20	0 48 40	9.02520	9	10.97480	9.02766	9	10.97234	10.00245	0	9.99755	55
6	11 12	48 48	02639	11	97361	02885	11	97115	00247	0	99753	54
7	11 4	48 56	02757	13	97243	03005	13	96995	00248	0	99752	53
8	10 56	49 4	02874	15	97126	03124	15	96876	00249	0	99751	52
9	10 48	49 12	02992	17	97008	03242	17	96758	00251	0	99749	51
10	11 10 40	0 49 20	9.03109	19	10.96891	9.03361	19	10.96639	10.00252	0	9.99748	50
11	10 32	49 28	03226	20	96774	03479	21	96521	00253	0	99747	49
12	10 24	49 36	03342	22	96658	03597	23	96403	00255	0	99745	48
13	10 16	49 44	03458	24	96542	03714	24	96286	00256	0	99744	47
14	10 8	49 52	03574	26	96426	03832	26	96168	00258	0	99742	46
15	11 10 0	0 50 0	9.03690	28	10.96310	9.03948	28	10.96052	10.00259	0	9.99741	45
16	9 52	50 8	03805	30	96195	04065	30	95935	00260	0	99740	44
17	9 44	50 16	03920	31	96080	04181	32	95819	00262	0	99738	43
18	9 36	50 24	04034	33	95966	04297	34	95703	00263	0	99737	42
19	9 28	50 32	04149	35	95851	04413	36	95587	00264	0	99736	41
20	11 9 20	0 50 40	9.04262	37	10.95738	9.04528	38	10.95472	10.00266	0	9.99734	40
21	9 12	50 48	04376	39	95624	04643	39	95357	00267	1	99733	39
22	9 4	50 56	04490	41	95510	04758	41	95242	00269	1	99731	38
23	8 56	51 4	04603	43	95397	04873	43	95127	00270	1	99730	37
24	8 48	51 12	04715	44	95285	04987	45	95013	00272	1	99728	36
25	11 8 40	0 51 20	9.04828	46	10.95172	9.05101	47	10.94899	10.00273	1	9.99727	35
26	8 32	51 28	04940	48	95060	05214	49	94786	00274	1	99726	34
27	8 24	51 36	05052	50	94948	05328	51	94672	00276	1	99724	33
28	8 16	51 44	05164	52	94836	05441	53	94559	00277	1	99723	32
29	8 8	51 52	05275	54	94725	05553	54	94447	00279	1	99721	31
30	11 8 0	0 52 0	9.05386	56	10.94614	9.05666	56	10.94334	10.00280	1	9.99720	30
31	7 52	52 8	05497	57	94503	05778	58	94222	00282	1	99718	29
32	7 44	52 16	05607	59	94393	05890	60	94110	00283	1	99717	28
33	7 36	52 24	05717	61	94283	06002	62	93998	00284	1	99716	27
34	7 28	52 32	05827	63	94173	06113	64	93887	00286	1	99714	26
35	11 7 20	0 52 40	9.05937	65	10.94063	9.06224	66	10.93776	10.00287	1	9.99713	25
36	7 12	52 48	06046	67	93954	06335	68	93665	00289	1	99711	24
37	7 4	52 56	06155	69	93845	06445	69	93555	00290	1	99710	23
38	6 56	53 4	06264	70	93736	06556	71	93444	00292	1	99708	22
39	6 48	53 12	06372	72	93628	06666	73	93334	00293	1	99707	21
40	11 6 40	0 53 20	9.06481	74	10.93519	9.06775	75	10.93225	10.00295	1	9.99705	20
41	6 32	53 28	06589	76	93411	06885	77	93115	00296	1	99704	19
42	6 24	53 36	06696	78	93304	06994	79	93006	00298	1	99702	18
43	6 16	53 44	06804	80	93196	07103	81	92897	00299	1	99701	17
44	6 8	53 52	06911	81	93089	07211	83	92789	00301	1	99699	16
45	11 6 0	0 54 0	9.07018	83	10.92982	9.07320	84	10.92680	10.00302	1	9.99698	15
46	5 52	54 8	07124	85	92876	07428	86	92572	00304	1	99696	14
47	5 44	54 16	07231	87	92769	07536	88	92464	00305	1	99695	13
48	5 36	54 24	07337	89	92663	07643	90	92357	00307	1	99693	12
49	5 28	54 32	07442	91	92558	07751	92	92249	00308	1	99692	11
50	11 5 20	0 54 40	9.07548	93	10.92452	9.07858	94	10.92142	10.00310	1	9.99690	10
51	5 12	54 48	07653	94	92347	07964	96	92036	00311	1	99689	9
52	5 4	54 56	07758	96	92242	08071	98	91929	00313	1	99687	8
53	4 56	55 4	07863	98	92137	08177	99	91823	00314	1	99686	7
54	4 48	55 12	07968	100	92032	08283	101	91717	00316	1	99684	6
55	11 4 40	0 55 20	9.08072	102	10.91928	9.08389	103	10.91611	10.00317	1	9.99683	5
56	4 32	55 28	08176	104	91824	08495	105	91505	00319	1	99681	4
57	4 24	55 36	08280	106	91720	08600	107	91400	00320	1	99680	3
58	4 16	55 44	08383	107	91617	08705	109	91295	00322	1	99678	2
59	4 8	55 52	08486	109	91514	08810	111	91190	00323	1	99677	1
60	4 0	56 0	08589	111	91411	08914	113	91086	00325	1	99675	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine	M
96°			A		A	B		B	C		C	83°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	14	28	42	56	69	83	97
	B	14	28	42	56	70	84	98
	C	0	0	1	1	1	1	1

Digitized by Google

TABLE XXVII.

S. Log. Sines, Tangents, and Secants. G'.

			A		A	B		B	C		C	
7°											172°	
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant	Diff.	Cosine.	M
0	11 4 0	0 56 0	9.08589	0	10.91411	9.08914	0	10.91086	10.00325	0	9.99675	60
1	3 52	56 8	08692	2	91308	09019	2	90981	00326	0	99674	59
2	3 44	56 16	08795	3	91205	09123	3	90877	00328	0	99672	58
3	3 36	56 24	08897	5	91103	09227	5	90773	00330	0	99670	57
4	3 28	56 32	08999	6	91001	09330	7	90670	00331	0	99669	56
5	11 3 20	0 56 40	9.09101	8	10.90899	9.09434	8	10.90566	10.00333	0	9.99667	55
6	3 12	56 48	09202	10	90798	09537	10	90463	00334	0	99666	54
7	3 4	56 56	09304	11	90696	09640	11	90360	00336	0	99664	53
8	2 56	57 4	09405	13	90595	09742	13	90258	00337	0	99663	52
9	2 48	57 12	09506	14	90494	09845	15	90155	00339	0	99661	51
10	11 2 40	0 57 20	9.09606	16	10.90394	9.09947	16	10.90053	10.00341	0	9.99659	50
11	2 32	57 28	09707	18	90293	10049	18	89951	00342	0	99658	49
12	2 24	57 36	09807	19	90193	10150	20	89850	00344	0	99656	48
13	2 16	57 44	09907	21	90093	10252	21	89748	00345	0	99655	47
14	2 8	57 52	10006	22	89994	10353	23	89647	00347	0	99653	46
15	11 2 0	0 58 0	9.10106	24	10.89894	9.10454	24	10.89546	10.00349	0	9.99651	45
16	1 52	58 8	10205	26	89795	10555	26	89445	00350	0	99650	44
17	1 44	58 16	10304	27	89696	10656	28	89344	00352	0	99648	43
18	1 36	58 24	10402	29	89598	10756	29	89244	00353	1	99647	42
19	1 28	58 32	10501	30	89499	10856	31	89144	00355	1	99645	41
20	11 1 20	0 58 40	9.10599	32	10.89401	9.10956	33	10.89044	10.00357	1	9.99643	40
21	1 12	58 48	10697	34	89303	11056	34	88944	00358	1	99642	39
22	1 4	58 56	10795	35	89205	11155	36	88845	00360	1	99640	38
23	0 56	59 4	10893	37	89107	11254	37	88746	00362	1	99638	37
24	0 48	59 12	10990	38	89010	11353	39	88647	00363	1	99637	36
25	11 0 40	0 59 20	9.11087	40	10.88913	9.11452	41	10.88548	10.00365	1	9.99635	35
26	0 32	59 28	11184	42	88816	11551	42	88449	00367	1	99633	34
27	0 24	59 36	11281	43	88719	11649	44	88351	00368	1	99632	33
28	0 16	59 44	11377	45	88623	11747	46	88253	00370	1	99630	32
29	0 8	59 52	11474	46	88526	11845	47	88155	00371	1	99629	31
30	11 0 0	1 0 0	9.11570	48	10.88430	9.11943	49	10.88057	10.00373	1	9.99627	30
31	10 59 52	0 8	11666	50	88334	12040	51	87960	00375	1	99625	29
32	59 44	0 16	11761	51	88239	12138	52	87862	00376	1	99624	28
33	59 36	0 24	11857	53	88143	12235	54	87765	00378	1	99622	27
34	59 28	0 32	11952	54	88048	12332	55	87668	00380	1	99620	26
35	10 59 20	1 0 40	9.12047	56	10.87953	9.12428	57	10.87572	10.00382	1	9.99618	25
36	59 12	0 48	12142	58	87858	12525	59	87475	00383	1	99617	24
37	59 4	0 56	12236	59	87764	12621	60	87379	00385	1	99615	23
38	58 56	1 4	12331	61	87669	12717	62	87283	00387	1	99613	22
39	58 48	1 12	12425	62	87575	12813	64	87187	00388	1	99612	21
40	10 58 40	1 1 20	9.12519	64	10.87481	9.12909	65	10.87091	10.00390	1	9.99610	20
41	58 32	1 28	12612	66	87388	13004	67	86996	00392	1	99608	19
42	58 24	1 36	12706	67	87294	13099	68	86901	00393	1	99607	18
43	58 16	1 44	12799	69	87201	13194	70	86806	00395	1	99605	17
44	58 8	1 52	12892	70	87108	13289	72	86711	00397	1	99603	16
45	10 58 0	1 2 0	9.12985	72	10.87015	9.13384	73	10.86616	10.00399	1	9.99601	15
46	57 52	2 8	13078	74	86922	13478	75	86522	00400	1	99600	14
47	57 44	2 16	13171	75	86829	13573	77	86427	00402	1	99598	13
48	57 36	2 24	13263	77	86737	13667	78	86333	00404	1	99596	12
49	57 28	2 32	13355	78	86645	13761	80	86239	00405	1	99595	11
50	10 57 20	1 2 40	9.13447	80	10.86553	9.13854	81	10.86146	10.00407	1	9.99593	10
51	57 12	2 48	13539	82	86461	13948	83	86052	00409	1	99591	9
52	57 4	2 56	13630	83	86370	14041	85	85959	00411	1	99589	8
53	56 56	3 4	13722	85	86278	14134	86	85866	00412	1	99588	7
54	56 48	3 12	13813	87	86187	14227	88	85773	00414	2	99586	6
55	10 56 40	1 3 20	9.13904	88	10.86096	9.14320	90	10.85680	10.00416	2	9.99584	5
56	56 32	3 28	13994	90	86006	14412	91	85588	00418	2	99582	4
57	56 24	3 36	14085	91	85915	14504	93	85496	00419	2	99581	3
58	56 16	3 44	14175	93	85825	14597	95	85403	00421	2	99579	2
59	56 8	3 52	14266	95	85734	14688	96	85312	00423	2	99577	1
60	56 0	4 0	14356	96	85644	14780	98	85220	00425	2	99575	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
97°			A		A	B		B	C		C	82°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	12	24	36	48	60	72	84
	B	12	24	37	49	61	73	86
	C	0	0	1	1	1	1	1

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

S 8° — G 171°

M	Hour A.M.	Hour P.M.	A Sine.	Diff.	A Cosecant.	B Tangent.	Diff.	B Cotangent	C Secant.	Diff.	C Cosine.	M
0	10 56 0	1 4 0	9.14356	0	10.85644	9.14780	0	10.85220	10.00425	0	9.99575	60
1	55 52	4 8	14445	1	85555	14872	1	85128	00426	0	99574	59
2	55 44	4 16	14535	3	85465	14963	3	85037	00428	0	99572	58
3	55 36	4 24	14624	4	85376	15054	4	84946	00430	0	99570	57
4	55 28	4 32	14714	6	85286	15145	6	84855	00432	0	99568	56
5	10 55 20	1 4 40	9.14803	7	10.85197	9.15236	7	10.84764	10.00434	0	9.99566	55
6	55 12	4 48	14891	8	85109	15327	9	84673	00435	0	99565	54
7	55 4	4 56	14980	10	85020	15417	10	84583	00437	0	99563	53
8	54 56	5 4	15069	11	84931	15508	12	84492	00439	0	99561	52
9	54 48	5 12	15157	13	84843	15598	13	84402	00441	0	99559	51
10	10 54 40	1 5 20	9.15245	14	10.84755	9.15688	14	10.84312	10.00443	0	9.99557	50
11	54 32	5 28	15333	16	84667	15777	16	84223	00444	0	99556	49
12	54 24	5 36	15421	17	84579	15867	17	84133	00446	0	99554	48
13	54 16	5 44	15508	18	84492	15956	19	84044	00448	0	99552	47
14	54 8	5 52	15596	20	84404	16046	20	83954	00450	0	99550	46
15	10 54 0	1 6 0	9.15683	21	10.84317	9.16135	22	10.83865	10.00452	0	9.99548	45
16	53 52	6 8	15770	23	84230	16224	23	83776	00454	1	99546	44
17	53 44	6 16	15857	24	84143	16312	25	83688	00455	1	99545	43
18	53 36	6 24	15944	25	84056	16401	26	83599	00457	1	99543	42
19	53 28	6 32	16030	27	83970	16489	27	83511	00459	1	99541	41
20	10 53 20	1 6 40	9.16116	28	10.83884	9.16577	29	10.83423	10.00461	1	9.99539	40
21	53 12	6 48	16203	30	83797	16665	30	83335	00463	1	99537	39
22	53 4	6 56	16289	31	83711	16753	32	83247	00465	1	99535	38
23	52 56	7 4	16374	32	83626	16841	33	83159	00467	1	99533	37
24	52 48	7 12	16460	34	83540	16928	35	83072	00468	1	99532	36
25	10 52 40	1 7 20	9.16545	35	10.83455	9.17016	36	10.82984	10.00470	1	9.99530	35
26	52 32	7 28	16631	37	83369	17103	37	82897	00472	1	99528	34
27	52 24	7 36	16716	38	83284	17190	39	82810	00474	1	99526	33
28	52 16	7 44	16801	39	83199	17277	40	82723	00476	1	99524	32
29	52 8	7 52	16886	41	83114	17363	42	82637	00478	1	99522	31
30	10 52 0	1 8 0	9.16970	42	10.83030	9.17450	43	10.82550	10.00480	1	9.99520	30
31	51 52	8 8	17055	44	82945	17536	45	82464	00482	1	99518	29
32	51 44	8 16	17139	45	82861	17622	46	82378	00483	1	99517	28
33	51 36	8 24	17223	47	82777	17708	48	82292	00485	1	99515	27
34	51 28	8 32	17307	48	82693	17794	49	82206	00487	1	99513	26
35	10 51 20	1 8 40	9.17391	49	10.82609	9.17880	50	10.82120	10.00489	1	9.99511	25
36	51 12	8 48	17474	51	82526	17965	52	82035	00491	1	99509	24
37	51 4	8 56	17558	52	82442	18051	53	81949	00493	1	99507	23
38	50 56	9 4	17641	54	82359	18136	55	81864	00495	1	99505	22
39	50 48	9 12	17724	55	82276	18221	56	81779	00497	1	99503	21
40	10 50 40	1 9 20	9.17807	56	10.82193	9.18306	58	10.81694	10.00499	1	9.99501	20
41	50 32	9 28	17890	58	82110	18391	59	81609	00501	1	99499	19
42	50 24	9 36	17973	59	82027	18475	61	81525	00503	1	99497	18
43	50 16	9 44	18055	61	81945	18560	62	81440	00505	1	99495	17
44	50 8	9 52	18137	62	81863	18644	63	81356	00506	1	99494	16
45	10 50 0	1 10 0	9.18220	63	10.81780	9.18728	65	10.81272	10.00508	1	9.99492	15
46	49 52	10 8	18302	65	81698	18812	66	81188	00510	1	99490	14
47	49 44	10 16	18383	66	81617	18896	68	81104	00512	1	99488	13
48	49 36	10 24	18465	68	81535	18979	69	81021	00514	2	99486	12
49	49 28	10 32	18547	69	81453	19063	71	80937	00516	2	99484	11
50	10 49 20	1 10 40	9.18628	71	10.81372	9.19146	72	10.80854	10.00518	2	9.99482	10
51	49 12	10 48	18709	72	81291	19229	74	80771	00520	2	99480	9
52	49 4	10 56	18790	73	81210	19312	75	80688	00522	2	99478	8
53	48 56	11 4	18871	75	81129	19395	76	80605	00524	2	99476	7
54	48 48	11 12	18952	76	81048	19478	78	80522	00526	2	99474	6
55	10 48 40	1 11 20	9.19033	78	10.80967	9.19561	79	10.80439	10.00528	2	9.99472	5
56	48 32	11 28	19113	79	80887	19643	81	80357	00530	2	99470	4
57	48 24	11 36	19193	80	80807	19725	82	80275	00532	2	99468	3
58	48 16	11 44	19273	82	80727	19807	84	80193	00534	2	99466	2
59	48 8	11 52	19353	83	80647	19889	85	80111	00536	2	99464	1
60	48 0	12 0	19433	85	80567	19971	87	80029	00538	2	99462	0
M	Hour P.M.	Hour A.M.	A Cosine.	Diff.	A Secant.	B Cotangent	Diff.	B Tangent.	C Cosecant.	Diff.	C Sine.	M

98° — 81°

Seconds of time ……		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	11	21	32	42	53	63	74
	B	11	22	32	43	54	65	76
	C	0	0	1	1	1	1	2

Digitized by Google

TABLE XXVII.

9h. Log. Sines, Tangents, and Secants. 6h.

9°			A		A	B		B	C		C	170°
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	10 48 0	1 12 0	9.19433	0	10.80567	9.19971	0	10.80029	10.00538	0	9.99462	60
1	47 52	12 8	19513	1	80487	20053	1	79947	00540	0	99460	59
2	47 44	12 16	19592	3	80408	20134	3	79866	00542	0	99458	58
3	47 36	12 24	19672	4	80328	20216	4	79784	00544	0	99456	57
4	47 28	12 32	19751	5	80249	20297	5	79703	00546	0	99454	56
5	10 47 20	1 12 40	9.19830	6	10.80170	9.20378	6	10.79622	10.00548	0	9.99452	55
6	47 12	12 48	19909	8	80091	20459	8	79541	00550	0	99450	54
7	47 4	12 56	19988	9	80012	20540	9	79460	00552	0	99448	53
8	46 56	13 4	20067	10	79933	20621	10	79379	00554	0	99446	52
9	46 48	13 12	20145	11	79855	20701	12	79299	00556	0	99444	51
10	10 46 40	1 13 20	9.20223	13	10.79777	9.20782	13	10.79218	10.00558	0	9.99442	50
11	46 32	13 28	20302	14	79698	20862	14	79138	00560	0	99440	49
12	46 24	13 36	20380	15	79620	20942	16	79058	00562	0	99438	48
13	46 16	13 44	20458	16	79542	21022	17	78978	00564	0	99436	47
14	46 8	13 52	20535	18	79465	21102	18	78898	00566	0	99434	46
15	10 46 0	1 14 0	9.20613	19	10.79387	9.21182	19	10.78818	10.00568	1	9.99432	45
16	45 52	14 8	20691	20	79309	21261	21	78739	00571	1	99429	44
17	45 44	14 16	20768	21	79232	21341	22	78659	00573	1	99427	43
18	45 36	14 24	20845	23	79155	21420	23	78580	00575	1	99425	42
19	45 28	14 32	20922	24	79078	21499	25	78501	00577	1	99423	41
20	10 45 20	1 14 40	9.20999	25	10.79001	9.21578	26	10.78422	10.00579	1	9.99421	40
21	45 12	14 48	21076	26	78924	21657	27	78343	00581	1	99419	39
22	45 4	14 56	21153	28	78847	21736	28	78264	00583	1	99417	38
23	44 56	15 4	21229	29	78771	21814	30	78186	00585	1	99415	37
24	44 48	15 12	21306	30	78694	21893	31	78107	00587	1	99413	36
25	10 44 40	1 15 20	9.21382	31	10.78618	9.21971	32	10.78029	10.00589	1	9.99411	35
26	44 32	15 28	21458	33	78542	22049	34	77951	00591	1	99409	34
27	44 24	15 36	21534	34	78466	22127	35	77873	00593	1	99407	33
28	44 16	15 44	21610	35	78390	22205	36	77795	00596	1	99404	32
29	44 8	15 52	21685	37	78315	22283	38	77717	00598	1	99402	31
30	10 44 0	1 16 0	9.21761	38	10.78239	9.22361	39	10.77639	10.00600	1	9.99400	30
31	43 52	16 8	21836	39	78164	22438	40	77562	00602	1	99398	29
32	43 44	16 16	21912	40	78088	22516	41	77484	00604	1	99396	28
33	43 36	16 24	21987	42	78013	22593	43	77407	00606	1	99394	27
34	43 28	16 32	22062	43	77938	22670	44	77330	00608	1	99392	26
35	10 43 20	1 16 40	9.22137	44	10.77863	9.22747	45	10.77253	10.00610	1	9.99390	25
36	43 12	16 48	22211	45	77789	22824	47	77176	00612	1	99388	24
37	43 4	16 56	22286	47	77714	22901	48	77099	00615	1	99385	23
38	42 56	17 4	22361	48	77639	22977	49	77023	00617	1	99383	22
39	42 48	17 12	22435	49	77565	23054	50	76946	00619	1	99381	21
40	10 42 40	1 17 20	9.22509	50	10.77491	9.23130	52	10.76870	10.00621	1	9.99379	20
41	42 32	17 28	22583	52	77417	23206	53	76794	00623	1	99377	19
42	42 24	17 36	22657	53	77343	23283	54	76717	00625	1	99375	18
43	42 16	17 44	22731	54	77269	23359	56	76641	00628	2	99372	17
44	42 8	17 52	22805	55	77195	23435	57	76565	00630	2	99370	16
45	10 42 0	1 18 0	9.22878	57	10.77122	9.23510	58	10.76490	10.00632	2	9.99368	15
46	41 52	18 8	22952	58	77048	23586	60	76414	00634	2	99366	14
47	41 44	18 16	23025	59	76975	23661	61	76339	00636	2	99364	13
48	41 36	18 24	23098	60	76902	23737	62	76263	00638	2	99362	12
49	41 28	18 32	23171	62	76829	23812	63	76188	00641	2	99359	11
50	10 41 20	1 18 40	9.23244	63	10.76756	9.23887	65	10.76113	10.00643	2	9.99357	10
51	41 12	18 48	23317	64	76683	23962	66	76038	00645	2	99355	9
52	41 4	18 56	23390	65	76610	24037	67	75963	00647	2	99353	8
53	40 56	19 4	23462	67	76538	24112	69	75888	00649	2	99351	7
54	40 48	19 12	23535	68	76465	24186	70	75814	00652	2	99348	6
55	10 40 40	1 19 20	9.23607	69	10.76393	9.24261	71	10.75739	10.00654	2	9.99346	5
56	40 32	19 28	23679	71	76321	24335	73	75665	00656	2	99344	4
57	40 24	19 36	23752	72	76248	24410	74	75590	00658	2	99342	3
58	40 16	19 44	23823	73	76177	24484	75	75516	00660	2	99340	2
59	40 8	19 52	23895	74	76105	24558	76	75442	00663	2	99337	1
60	40 0	20 0	23967	76	76033	24632	78	75368	00665	2	99335	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
99°			A		A	B		B	C		C	80°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	9	19	28	38	47	57	66
	B	10	19	29	39	49	58	68
	C	0	1	1	1	1	2	2

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

S'. 10° | A | A | B | B | C | C | G'. 169°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	10 40 0	1 20 0	9.23967	0	10.76033	9.24632	0	10.75368	10.00665	0	9.99335	60
1	39 52	20 8	24039	1	75961	24706	1	75294	00667	0	99333	59
2	39 44	20 16	24110	2	75890	24779	2	75221	00669	0	99331	58
3	39 36	20 24	24181	3	75819	24853	4	75147	00672	0	99328	57
4	39 28	20 32	24253	5	75747	24926	5	75074	00674	0	99326	56
5	10 39 20	1 20 40	9.24324	6	10.75676	9.25000	6	10.75000	10.00676	0	9.99324	55
6	39 12	20 48	24395	7	75605	25073	7	74927	00678	0	99322	54
7	39 4	20 56	24466	8	75534	25146	8	74854	00681	0	99319	53
8	38 56	21 4	24536	9	75464	25219	9	74781	00683	0	99317	52
9	38 48	21 12	24607	10	75393	25292	11	74708	00685	0	99315	51
10	10 38 40	1 21 20	9.24677	11	10.75323	9.25365	12	10.74635	10.00687	0	9.99313	50
11	38 32	21 28	24748	13	75252	25437	13	74563	00690	0	99310	49
12	38 24	21 36	24818	14	75182	25510	14	74490	00692	0	99308	48
13	38 16	21 44	24888	15	75112	25582	15	74418	00694	1	99306	47
14	38 8	21 52	24958	16	75042	25655	16	74345	00696	1	99304	46
15	10 38 0	1 22 0	9.25028	17	10.74972	9.25727	18	10.74273	10.00699	1	9.99301	45
16	37 52	22 8	25098	18	74902	25799	19	74201	00701	1	99299	44
17	37 44	22 16	25168	19	74832	25871	20	74129	00703	1	99297	43
18	37 36	22 24	25237	20	74763	25943	21	74057	00706	1	99294	42
19	37 28	22 32	25307	22	74693	26015	22	73985	00708	1	99292	41
20	10 37 20	1 22 40	9.25376	23	10.74624	9.26086	24	10.73914	10.00710	1	9.99290	40
21	37 12	22 48	25445	24	74555	26158	25	73842	00712	1	99288	39
22	37 4	22 56	25514	25	74486	26229	26	73771	00715	1	99285	38
23	36 56	23 4	25583	26	74417	26301	27	73699	00717	1	99283	37
24	36 48	23 12	25652	27	74348	26372	28	73628	00719	1	99281	36
25	10 36 40	1 23 20	9.25721	28	10.74279	9.26443	29	10.73557	10.00722	1	9.99278	35
26	36 32	23 28	25790	30	74210	26514	31	73486	00724	1	99276	34
27	36 24	23 36	25858	31	74142	26585	32	73415	00726	1	99274	33
28	36 16	23 44	25927	32	74073	26655	33	73345	00729	1	99271	32
29	36 8	23 52	25995	33	74005	26726	34	73274	00731	1	99269	31
30	10 36 0	1 24 0	9.26063	34	10.73937	9.26797	35	10.73203	10.00733	1	9.99267	30
31	35 52	24 8	26131	35	73869	26867	36	73133	00736	1	99264	29
32	35 44	24 16	26199	36	73801	26937	38	73063	00738	1	99262	28
33	35 36	24 24	26267	38	73733	27008	39	72992	00740	1	99260	27
34	35 28	24 32	26335	39	73665	27078	40	72922	00743	1	99257	26
35	10 35 20	1 24 40	9.26403	40	10.73597	9.27148	41	10.72852	10.00745	1	9.99255	25
36	35 12	24 48	26470	41	73530	27218	42	72782	00748	1	99252	24
37	35 4	24 56	26538	42	73462	27288	44	72712	00750	1	99250	23
38	34 56	25 4	26605	43	73395	27357	45	72643	00752	1	99248	22
39	34 48	25 12	26672	44	73328	27427	46	72573	00755	2	99245	21
40	10 34 40	1 25 20	9.26739	45	10.73261	9.27496	47	10.72504	10.00757	2	9.99243	20
41	34 32	25 28	26806	47	73194	27566	48	72434	00759	2	99241	19
42	34 24	25 36	26873	48	73127	27635	49	72365	00762	2	99238	18
43	34 16	25 44	26940	49	73060	27704	51	72296	00764	2	99236	17
44	34 8	25 52	27007	50	72993	27773	52	72227	00767	2	99233	16
45	10 34 0	1 26 0	9.27073	51	10.72927	9.27842	53	10.72158	10.00769	2	9.99231	15
46	33 52	26 8	27140	52	72860	27911	54	72089	00771	2	99229	14
47	33 44	26 16	27206	53	72794	27980	55	72020	00774	2	99226	13
48	33 36	26 24	27273	55	72727	28049	56	71951	00776	2	99224	12
49	33 28	26 32	27339	56	72661	28117	58	71883	00779	2	99221	11
50	10 33 20	1 26 40	9.27405	57	10.72595	9.28186	59	10.71814	10.00781	2	9.99219	10
51	33 12	26 48	27471	58	72529	28254	60	71746	00783	2	99217	9
52	33 4	26 56	27537	59	72463	28323	61	71677	00786	2	99214	8
53	32 56	27 4	27602	60	72398	28391	62	71609	00788	2	99212	7
54	32 48	27 12	27668	61	72332	28459	63	71541	00791	2	99209	6
55	10 32 40	1 27 20	9.27734	63	10.72266	9.28527	65	10.71473	10.00793	2	9.99207	5
56	32 32	27 28	27799	64	72201	28595	66	71405	00796	2	99204	4
57	32 24	27 36	27864	65	72136	28662	67	71338	00798	2	99202	3
58	32 16	27 44	27930	66	72070	28730	68	71270	00800	2	99200	2
59	32 8	27 52	27995	67	72005	28798	69	71202	00803	2	99197	1
60	32 0	28 0	28060	68	71940	28865	71	71135	00805	2	99195	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

100° | A | A | B | B | C | C | 79°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	9	17	26	34	43	51	60
	B	9	18	26	35	44	53	62
	C	0	1	1	1	1	2	2

Digitized by Google

TABLE XXVII.

9'. **Log. Sines, Tangents, and Secants.** G'.

9°			A		A	B		B	C		C	170°
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	10 48 0	1 12 0	9.19433	0	10.80567	9.19971	0	10.80029	10.00538	0	9.99462	60
1	47 52	12 8	19513	1	80487	20053	1	79947	00540	0	99460	59
2	47 44	12 16	19592	3	80408	20134	3	79866	00542	0	99458	58
3	47 36	12 24	19672	4	80328	20216	4	79784	00544	0	99456	57
4	47 28	12 32	19751	5	80249	20297	5	79703	00546	0	99454	56
5	10 47 20	1 12 40	9.19830	6	10.80170	9.20378	6	10.79622	10.00548	0	9.99452	55
6	47 12	12 48	19909	8	80091	20459	8	79541	00550	0	99450	54
7	47 4	12 56	19988	9	80012	20540	9	79460	00552	0	99448	53
8	46 56	13 4	20067	10	79933	20621	10	79379	00554	0	99446	52
9	46 48	13 12	20145	11	79855	20701	12	79299	00556	0	99444	51
10	10 46 40	1 13 20	9.20223	13	10.79777	9.20782	13	10.79218	10.00558	0	9.99442	50
11	46 32	13 28	20302	14	79698	20862	14	79138	00560	0	99440	49
12	46 24	13 36	20380	15	79620	20942	16	79058	00562	0	99438	48
13	46 16	13 44	20458	16	79542	21022	17	78978	00564	0	99436	47
14	46 8	13 52	20535	18	79465	21102	18	78898	00566	0	99434	46
15	10 46 0	1 14 0	9.20613	19	10.79387	9.21182	19	10.78818	10.00568	1	9.99432	45
16	45 52	14 8	20691	20	79309	21261	21	78739	00571	1	99429	44
17	45 44	14 16	20768	21	79232	21341	22	78659	00573	1	99427	43
18	45 36	14 24	20845	23	79155	21420	23	78580	00575	1	99425	42
19	45 28	14 32	20922	24	79078	21499	25	78501	00577	1	99423	41
20	10 45 20	1 14 40	9.20999	25	10.79001	9.21578	26	10.78422	10.00579	1	9.99421	40
21	45 12	14 48	21076	26	78924	21657	27	78343	00581	1	99419	39
22	45 4	14 56	21153	28	78847	21736	28	78264	00583	1	99417	38
23	44 56	15 4	21229	29	78771	21814	30	78186	00585	1	99415	37
24	44 48	15 12	21306	30	78694	21893	31	78107	00587	1	99413	36
25	10 44 40	1 15 20	9.21382	31	10.78618	9.21971	32	10.78029	10.00589	1	9.99411	35
26	44 32	15 28	21458	33	78542	22049	34	77951	00591	1	99409	34
27	44 24	15 36	21534	34	78466	22127	35	77873	00593	1	99407	33
28	44 16	15 44	21610	35	78390	22205	36	77795	00596	1	99404	32
29	44 8	15 52	21685	37	78315	22283	38	77717	00598	1	99402	31
30	10 44 0	1 16 0	9.21761	38	10.78239	9.22361	39	10.77639	10.00600	1	9.99400	30
31	43 52	16 8	21836	39	78164	22438	40	77562	00602	1	99398	29
32	43 44	16 16	21912	40	78088	22516	41	77484	00604	1	99396	28
33	43 36	16 24	21987	42	78013	22593	43	77407	00606	1	99394	27
34	43 28	16 32	22062	43	77938	22670	44	77330	00608	1	99392	26
35	10 43 20	1 16 40	9.22137	44	10.77863	9.22747	45	10.77253	10.00610	1	9.99390	25
36	43 12	16 48	22211	45	77789	22824	47	77176	00612	1	99388	24
37	43 4	16 56	22286	47	77714	22901	48	77099	00615	1	99385	23
38	42 56	17 4	22361	48	77639	22977	49	77023	00617	1	99383	22
39	42 48	17 12	22435	49	77565	23054	50	76946	00619	1	99381	21
40	10 42 40	1 17 20	9.22509	50	10.77491	9.23130	52	10.76870	10.00621	1	9.99379	20
41	42 32	17 28	22583	52	77417	23206	53	76794	00623	1	99377	19
42	42 24	17 36	22657	53	77343	23283	54	76717	00625	1	99375	18
43	42 16	17 44	22731	54	77269	23359	56	76641	00628	2	99372	17
44	42 8	17 52	22805	55	77195	23435	57	76565	00630	2	99370	16
45	10 42 0	1 18 0	9.22878	57	10.77122	9.23510	58	10.76490	10.00632	2	9.99368	15
46	41 52	18 8	22952	58	77048	23586	60	76414	00634	2	99366	14
47	41 44	18 16	23025	59	76975	23661	61	76339	00636	2	99364	13
48	41 36	18 24	23098	60	76902	23737	62	76263	00638	2	99362	12
49	41 28	18 32	23171	62	76829	23812	63	76188	00641	2	99359	11
50	10 41 20	1 18 40	9.23244	63	10.76756	9.23887	65	10.76113	10.00643	2	9.99357	10
51	41 12	18 48	23317	64	76683	23962	66	76038	00645	2	99355	9
52	41 4	18 56	23390	65	76610	24037	67	75963	00647	2	99353	8
53	40 56	19 4	23462	67	76538	24112	69	75888	00649	2	99351	7
54	40 48	19 12	23535	68	76465	24186	70	75814	00652	2	99348	6
55	10 40 40	1 19 20	9.23607	69	10.76393	9.24261	71	10.75739	10.00654	2	9.99346	5
56	40 32	19 28	23679	71	76321	24335	73	75665	00656	2	99344	4
57	40 24	19 36	23752	72	76248	24410	74	75590	00658	2	99342	3
58	40 16	19 44	23823	73	76177	24484	75	75516	00660	2	99340	2
59	40 8	19 52	23895	74	76105	24558	76	75442	00663	2	99337	1
60	40 0	20 0	23967	76	76033	24632	78	75368	00665	2	99335	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
99°			A		A	B		B	C		C	80°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	9	19	28	38	47	57	66
	B	10	19	29	39	49	58	68
	C	0	1	1	1	1	2	2

Digitized by Google

TABLE XXVII.

S'. G'.

Log. Sines, Tangents, and Secants.

10° A A B B C C 169°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	10 40 0	1 20 0	9.23967	0	10.76033	9.24632	0	10.75368	10.00665	0	9.99335	60
1	39 52	20 8	24039	1	75961	24706	1	75294	00667	0	99333	59
2	39 44	20 16	24110	2	75890	24779	2	75221	00669	0	99331	58
3	39 36	20 24	24181	3	75819	24853	4	75147	00672	0	99328	57
4	39 28	20 32	24253	5	75747	24926	5	75074	00674	0	99326	56
5	10 39 20	1 20 40	9.24324	6	10.75676	9.25000	6	10.75000	10.00676	0	9.99324	55
6	39 12	20 48	24395	7	75605	25073	7	74927	00678	0	99322	54
7	39 4	20 56	24466	8	75534	25146	8	74854	00681	0	99319	53
8	38 56	21 4	24536	9	75464	25219	9	74781	00683	0	99317	52
9	38 48	21 12	24607	10	75393	25292	11	74708	00685	0	99315	51
10	10 38 40	1 21 20	9.24677	11	10.75323	9.25365	12	10.74635	10.00687	0	9.99313	50
11	38 32	21 28	24748	13	75252	25437	13	74563	00690	0	99310	49
12	38 24	21 36	24818	14	75182	25510	14	74490	00692	0	99308	48
13	38 16	21 44	24888	15	75112	25582	15	74418	00694	1	99306	47
14	38 8	21 52	24958	16	75042	25655	16	74345	00696	1	99304	46
15	10 38 0	1 22 0	9.25028	17	10.74972	9.25727	18	10.74273	10.00699	1	9.99301	45
16	37 52	22 8	25098	18	74902	25799	19	74201	00701	1	99299	44
17	37 44	22 16	25168	19	74832	25871	20	74129	00703	1	99297	43
18	37 36	22 24	25237	20	74763	25943	21	74057	00706	1	99294	42
19	37 28	22 32	25307	22	74693	26015	22	73985	00708	1	99292	41
20	10 37 20	1 22 40	9.25376	23	10.74624	9.26086	24	10.73914	10.00710	1	9.99290	40
21	37 12	22 48	25445	24	74555	26158	25	73842	00712	1	99288	39
22	37 4	22 56	25514	25	74486	26229	26	73771	00715	1	99285	38
23	36 56	23 4	25583	26	74417	26301	27	73699	00717	1	99283	37
24	36 48	23 12	25652	27	74348	26372	28	73628	00719	1	99281	36
25	10 36 40	1 23 20	9.25721	28	10.74279	9.26443	29	10.73557	10.00722	1	9.99278	35
26	36 32	23 28	25790	30	74210	26514	31	73486	00724	1	99276	34
27	36 24	23 36	25858	31	74142	26585	32	73415	00726	1	99274	33
28	36 16	23 44	25927	32	74073	26655	33	73345	00729	1	99271	32
29	36 8	23 52	25995	33	74005	26726	34	73274	00731	1	99269	31
30	10 36 0	1 24 0	9.26063	34	10.73937	9.26797	35	10.73203	10.00733	1	9.99267	30
31	35 52	24 8	26131	35	73869	26867	36	73133	00736	1	99264	29
32	35 44	24 16	26199	36	73801	26937	38	73063	00738	1	99262	28
33	35 36	24 24	26267	38	73733	27008	39	72992	00740	1	99260	27
34	35 28	24 32	26335	39	73665	27078	40	72922	00743	1	99257	26
35	10 35 20	1 24 40	9.26403	40	10.73597	9.27148	41	10.72852	10.00745	1	9.99255	25
36	35 12	24 48	26470	41	73530	27218	42	72782	00748	1	99252	24
37	35 4	24 56	26538	42	73462	27288	44	72712	00750	1	99250	23
38	34 56	25 4	26605	43	73395	27357	45	72643	00752	1	99248	22
39	34 48	25 12	26672	44	73328	27427	46	72573	00755	2	99245	21
40	10 34 40	1 25 20	9.26739	45	10.73261	9.27496	47	10.72504	10.00757	2	9.99243	20
41	34 32	25 28	26806	47	73194	27566	48	72434	00759	2	99241	19
42	34 24	25 36	26873	48	73127	27635	49	72365	00762	2	99238	18
43	34 16	25 44	26940	49	73060	27704	51	72296	00764	2	99236	17
44	34 8	25 52	27007	50	72993	27773	52	72227	00767	2	99233	16
45	10 34 0	1 26 0	9.27073	51	10.72927	9.27842	53	10.72158	10.00769	2	9.99231	15
46	33 52	26 8	27140	52	72860	27911	54	72089	00771	2	99229	14
47	33 44	26 16	27206	53	72794	27980	55	72020	00774	2	99226	13
48	33 36	26 24	27273	55	72727	28049	56	71951	00776	2	99224	12
49	33 28	26 32	27339	56	72661	28117	58	71883	00779	2	99221	11
50	10 33 20	1 26 40	9.27405	57	10.72595	9.28186	59	10.71814	10.00781	2	9.99219	10
51	33 12	26 48	27471	58	72529	28254	60	71746	00783	2	99217	9
52	33 4	26 56	27537	59	72463	28323	61	71677	00786	2	99214	8
53	32 56	27 4	27602	60	72398	28391	62	71609	00788	2	99212	7
54	32 48	27 12	27668	61	72332	28459	63	71541	00791	2	99209	6
55	10 32 40	1 27 20	9.27734	63	10.72266	9.28527	65	10.71473	10.00793	2	9.99207	5
56	32 32	27 28	27799	64	72201	28595	66	71405	00796	2	99204	4
57	32 24	27 36	27864	65	72136	28662	67	71338	00798	2	99202	3
58	32 16	27 44	27930	66	72070	28730	68	71270	00800	2	99200	2
59	32 8	27 52	27995	67	72005	28798	69	71202	00803	2	99197	1
60	32 0	28 0	28060	68	71940	28865	71	71135	00805	2	99195	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

100° A A B B C C 79°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	9	17	26	34	43	51	60
	B	9	18	26	35	44	53	62
	C	0	1	1	1	1	2	2

TABLE XXVII.

S'. G.

Log. Sines, Tangents, and Secants.

11°			A		A	B		B	C		C 168°	
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	10 32 0	1 28 0	9.28060	0	10.71940	9.28865	0	10.71135	10.00805	0	9.99195	60
1	31 52	28 8	28125	1	71875	28933	1	71067	00808	0	99192	59
2	31 44	28 16	28190	2	71810	29000	2	71000	00810	0	99190	58
3	31 36	28 24	28254	3	71746	29067	3	70933	00813	0	99187	57
4	31 28	28 32	28319	4	71681	29134	4	70866	00815	0	99185	56
5	10 31 20	1 28 40	9.28384	5	10.71616	9.29201	5	10.70799	10.00818	0	9.99182	55
6	31 12	28 48	28448	6	71552	29268	6	70732	00820	0	99180	54
7	31 4	28 56	28512	7	71488	29335	8	70665	00823	0	99177	53
8	30 56	29 4	28577	8	71423	29402	9	70598	00825	0	99175	52
9	30 48	29 12	28641	9	71359	29468	10	70532	00828	0	99172	51
10	10 30 40	1 29 20	9.28705	10	10.71295	9.29535	11	10.70465	10.00830	0	9.99170	50
11	30 32	29 28	28769	11	71231	29601	12	70399	00833	0	99167	49
12	30 24	29 36	28833	12	71167	29668	13	70332	00835	1	99165	48
13	30 16	29 44	28896	13	71104	29734	14	70266	00838	1	99162	47
14	30 8	29 52	28960	14	71040	29800	15	70200	00840	1	99160	46
15	10 30 0	1 30 0	9.29024	16	10.70976	9.29866	16	10.70134	10.00843	1	9.99157	45
16	29 52	30 8	29087	17	70913	29932	17	70068	00845	1	99155	44
17	29 44	30 16	29150	18	70850	29998	18	70002	00848	1	99152	43
18	29 36	30 24	29214	19	70786	30064	19	69936	00850	1	99150	42
19	29 28	30 32	29277	20	70723	30130	20	69870	00853	1	99147	41
20	10 29 20	1 30 40	9.29340	21	10.70660	9.30195	22	10.69805	10.00855	1	9.99145	40
21	29 12	30 48	29403	22	70597	30261	23	69739	00858	1	99142	39
22	29 4	30 56	29466	23	70534	30326	24	69674	00860	1	99140	38
23	28 56	31 4	29529	24	70471	30391	25	69609	00863	1	99137	37
24	28 48	31 12	29591	25	70409	30457	26	69543	00865	1	99135	36
25	10 28 40	1 31 20	9.29654	26	10.70346	9.30522	27	10.69478	10.00868	1	9.99132	35
26	28 32	31 28	29716	27	70284	30587	28	69413	00870	1	99130	34
27	28 24	31 36	29779	28	70221	30652	29	69348	00873	1	99127	33
28	28 16	31 44	29841	29	70159	30717	30	69283	00876	1	99124	32
29	28 8	31 52	29903	30	70097	30782	31	69218	00878	1	99122	31
30	10 28 0	1 32 0	9.29966	31	10.70034	9.30846	32	10.69154	10.00881	1	9.99119	30
31	27 52	32 8	30028	32	69972	30911	33	69089	00883	1	99117	29
32	27 44	32 16	30090	33	69910	30975	35	69025	00886	1	99114	28
33	27 36	32 24	30151	34	69849	31040	36	68960	00888	1	99112	27
34	27 28	32 32	30213	35	69787	31104	37	68896	00891	1	99109	26
35	10 27 20	1 32 40	9.30275	36	10.69725	9.31168	38	10.68832	10.00894	2	9.99106	25
36	27 12	32 48	30336	37	69664	31233	39	68767	00896	2	99104	24
37	27 4	32 56	30398	38	69602	31297	40	68703	00899	2	99101	23
38	26 56	33 4	30459	39	69541	31361	41	68639	00901	2	99099	22
39	26 48	33 12	30521	40	69479	31425	42	68575	00904	2	99096	21
40	10 26 40	1 33 20	9.30582	41	10.69418	9.31489	43	10.68511	10.00907	2	9.99093	20
41	26 32	33 28	30643	42	69357	31552	44	68448	00909	2	99091	19
42	26 24	33 36	30704	43	69296	31616	45	68384	00912	2	99088	18
43	26 16	33 44	30765	45	69235	31679	46	68321	00914	2	99086	17
44	26 8	33 52	30826	46	69174	31743	47	68257	00917	2	99083	16
45	10 26 0	1 34 0	9.30887	47	10.69113	9.31806	49	10.68194	10.00920	2	9.99080	15
46	25 52	34 8	30947	48	69053	31870	50	68130	00922	2	99078	14
47	25 44	34 16	31008	49	68992	31933	51	68067	00925	2	99075	13
48	25 36	34 24	31068	50	68932	31996	52	68004	00928	2	99072	12
49	25 28	34 32	31129	51	68871	32059	53	67941	00930	2	99070	11
50	10 25 20	1 34 40	9.31189	52	10.68811	9.32122	54	10.67878	10.00933	2	9.99067	10
51	25 12	34 48	31250	53	68750	32185	55	67815	00936	2	99064	9
52	25 4	34 56	31310	54	68690	32248	56	67752	00938	2	99062	8
53	24 56	35 4	31370	55	68630	32311	57	67689	00941	2	99059	7
54	24 48	35 12	31430	56	68570	32373	58	67627	00944	2	99056	6
55	10 24 40	1 35 20	9.31490	57	10.68510	9.32436	59	10.67564	10.00946	2	9.99054	5
56	24 32	35 28	31549	58	68451	32498	60	67502	00949	2	99051	4
57	24 24	35 36	31609	59	68391	32561	61	67439	00952	2	99048	3
58	24 16	35 44	31669	60	68331	32623	63	67377	00954	2	99046	2
59	24 8	35 52	31728	61	68272	32685	64	67315	00957	3	99043	1
60	24 0	36 0	31788	62	68212	32747	65	67253	00960	3	99040	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
101°			A		A	B		B	C		C 78°	

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	8	16	23	31	39	47	54
	B	8	16	24	32	40	49	57
	C	0	1	1	1	2	2	2

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

S. 12° | A | A | B | B | C | C 167° | G.

M	Hour A.M.	Hour P.M.	Sine. (A)	Diff.	Cosecant. (A)	Tangent. (B)	Diff.	Cotangent (B)	Secant. (C)	Diff.	Cosine. (C)	M
0	10 24 0	1 36 0	9.31788	0	10.68212	9.32747	0	10.67253	10.00960	0	9.99040	60
1	23 52	36 8	31847	1	68153	32810	1	67190	00962	0	99038	59
2	23 44	36 16	31907	2	68093	32872	2	67128	00965	0	99035	58
3	23 36	36 24	31966	3	68034	32933	3	67067	00968	0	99032	57
4	23 28	36 32	32025	4	67975	32995	4	67005	00970	0	99030	56
5	10 23 20	1 36 40	9.32084	5	10.67916	9.33057	5	10.66943	10.00973	0	9.99027	55
6	23 12	36 48	32143	6	67857	33119	6	66881	00976	0	99024	54
7	23 4	36 56	32202	7	67798	33180	7	66820	00978	0	99022	53
8	22 56	37 4	32261	8	67739	33242	8	66758	00981	0	99019	52
9	22 48	37 12	32319	9	67681	33303	9	66697	00984	0	99016	51
10	10 22 40	1 37 20	9.32378	10	10.67622	9.33365	10	10.66635	10.00987	0	9.99013	50
11	22 32	37 28	32437	10	67563	33426	11	66574	00989	1	99011	49
12	22 24	37 36	32495	11	67505	33487	12	66513	00992	1	99008	48
13	22 16	37 44	32553	12	67447	33548	13	66452	00995	1	99005	47
14	22 8	37 52	32612	13	67388	33609	14	66391	00998	1	99002	46
15	10 22 0	1 38 0	9.32670	14	10.67330	9.33670	15	10.66330	10.01000	1	9.99000	45
16	21 52	38 8	32728	15	67272	33731	16	66269	01003	1	98997	44
17	21 44	38 16	32786	16	67214	33792	17	66208	01006	1	98994	43
18	21 36	38 24	32844	17	67156	33853	18	66147	01009	1	98991	42
19	21 28	38 32	32902	18	67098	33913	19	66087	01011	1	98989	41
20	10 21 20	1 38 40	9.32960	19	10.67040	9.33974	20	10.66026	10.01014	1	9.98986	40
21	21 12	38 48	33018	20	66982	34034	21	65966	01017	1	98983	39
22	21 4	38 56	33075	21	66925	34095	22	65905	01020	1	98980	38
23	20 56	39 4	33133	22	66867	34155	23	65845	01022	1	98978	37
24	20 48	39 12	33190	23	66810	34215	24	65785	01025	1	98975	36
25	10 20 40	1 39 20	9.33248	24	10.66752	9.34276	25	10.65724	10.01028	1	9.98972	35
26	20 32	39 28	33305	25	66695	34336	26	65664	01031	1	98969	34
27	20 24	39 36	33362	26	66638	34396	27	65604	01033	1	98967	33
28	20 16	39 44	33420	27	66580	34456	28	65544	01036	1	98964	32
29	20 8	39 52	33477	28	66523	34516	29	65484	01039	1	98961	31
30	10 20 0	1 40 0	9.33534	29	10.66466	9.34576	30	10.65424	10.01042	1	9.98958	30
31	19 52	40 8	33591	29	66409	34635	31	65365	01045	1	98955	29
32	19 44	40 16	33647	30	66353	34695	32	65305	01047	1	98953	28
33	19 36	40 24	33704	31	66296	34755	33	65245	01050	2	98950	27
34	19 28	40 32	33761	32	66239	34814	34	65186	01053	2	98947	26
35	10 19 20	1 40 40	9.33818	33	10.66182	9.34874	35	10.65126	10.01056	2	9.98944	25
36	19 12	40 48	33874	34	66126	34933	36	65067	01059	2	98941	24
37	19 4	40 56	33931	35	66069	34992	37	65008	01062	2	98938	23
38	18 56	41 4	33987	36	66013	35051	38	64949	01064	2	98936	22
39	18 48	41 12	34043	37	65957	35111	39	64889	01067	2	98933	21
40	10 18 40	1 41 20	9.34100	38	10.65900	9.35170	40	10.64830	10.01070	2	9.98930	20
41	18 32	41 28	34156	39	65844	35229	41	64771	01073	2	98927	19
42	18 24	41 36	34212	40	65788	35288	42	64712	01076	2	98924	18
43	18 16	41 44	34268	41	65732	35347	43	64653	01079	2	98921	17
44	18 8	41 52	34324	42	65676	35405	44	64595	01081	2	98919	16
45	10 18 0	1 42 0	9.34380	43	10.65620	9.35464	45	10.64536	10.01084	2	9.98916	15
46	17 52	42 8	34436	44	65564	35523	46	64477	01087	2	98913	14
47	17 44	42 16	34491	45	65509	35581	47	64419	01090	2	98910	13
48	17 36	42 24	34547	46	65453	35640	48	64360	01093	2	98907	12
49	17 28	42 32	34602	47	65398	35698	49	64302	01096	2	98904	11
50	10 17 20	1 42 40	9.34658	48	10.65342	9.35757	50	10.64243	10.01099	2	9.98901	10
51	17 12	42 48	34713	48	65287	35815	51	64185	01102	2	98898	9
52	17 4	42 56	34769	49	65231	35873	52	64127	01104	2	98896	8
53	16 56	43 4	34824	50	65176	35931	53	64069	01107	2	98893	7
54	16 48	43 12	34879	51	65121	35989	54	64011	01110	3	98890	6
55	10 16 40	1 43 20	9.34934	52	10.65066	9.36047	55	10.63953	10.01113	3	9.98887	5
56	16 32	43 28	34989	53	65011	36105	56	63895	01116	3	98884	4
57	16 24	43 36	35044	54	64956	36163	57	63837	01119	3	98881	3
58	16 16	43 44	35099	55	64901	36221	58	63779	01122	3	98878	2
59	16 8	43 52	35154	56	64846	36279	59	63721	01125	3	98875	1
60	16 0	44 0	35209	57	64791	36336	60	63664	01128	3	98872	0
M	Hour P.M.	Hour A.M.	Cosine. (A)	Diff.	Secant. (A)	Cotangent (B)	Diff.	Tangent. (B)	Cosecant. (C)	Diff.	Sine. (C)	M

102° | A | A | B | B | C | C 77°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	7	14	21	29	36	43	50
	B	7	15	22	30	37	45	52
	C	0	1	1	1	2	2	2

Digitized by Google

TABLE XXVII.

87.

Log. Sines, Tangents, and Secants.

G

13°			A		A	B		B	C		C	166°
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M
0	10 16 0	1 44 0	9.35209	0	10.64791	9.36336	0	10.63664	10.01128	0	9.98872	60
1	15 52	44 8	35263	1	64737	36394	1	63606	01131	0	98869	59
2	15 44	44 16	35318	2	64682	36452	2	63548	01133	0	98867	58
3	15 36	44 24	35373	3	64627	36509	3	63491	01136	0	98864	57
4	15 28	44 32	35427	4	64573	36566	4	63434	01139	0	98861	56
5	10 15 20	1 44 40	9.35481	4	10.64519	9.36624	5	10.63376	10.01142	0	9.98858	55
6	15 12	44 48	35536	5	64464	36681	6	63319	01145	0	98855	54
7	15 4	44 56	35590	6	64410	36738	6	63262	01148	0	98852	53
8	14 56	45 4	35644	7	64356	36795	7	63205	01151	0	98849	52
9	14 48	45 12	35698	8	64302	36852	8	63148	01154	0	98846	51
10	10 14 40	1 45 20	9.35752	9	10.64248	9.36909	9	10.63091	10.01157	1	9.98843	50
11	14 32	45 28	35806	10	64194	36966	10	63034	01160	1	98840	49
12	14 24	45 36	35860	11	64140	37023	11	62977	01163	1	98837	48
13	14 16	45 44	35914	11	64086	37080	12	62920	01166	1	98834	47
14	14 8	45 52	35968	12	64032	37137	13	62863	01169	1	98831	46
15	10 14 0	1 46 0	9.36022	13	10.63978	9.37193	14	10.62807	10.01172	1	9.98828	45
16	13 52	46 8	36075	14	63925	37250	15	62750	01175	1	98825	44
17	13 44	46 16	36129	15	63871	37306	16	62694	01178	1	98822	43
18	13 36	46 24	36182	16	63818	37363	17	62637	01181	1	98819	42
19	13 28	46 32	36236	17	63764	37419	18	62581	01184	1	98816	41
20	10 13 20	1 46 40	9.36289	18	10.63711	9.37476	19	10.62524	10.01187	1	9.98813	40
21	13 12	46 48	36342	18	63658	37532	19	62468	01190	1	98810	39
22	13 4	46 56	36395	19	63605	37588	20	62412	01193	1	98807	38
23	12 56	47 4	36449	20	63551	37644	21	62356	01196	1	98804	37
24	12 48	47 12	36502	21	63498	37700	22	62300	01199	1	98801	36
25	10 12 40	1 47 20	9.36555	22	10.63445	9.37756	23	10.62244	10.01202	1	9.98798	35
26	12 32	47 28	36608	23	63392	37812	24	62188	01205	1	98795	34
27	12 24	47 36	36660	24	63340	37868	25	62132	01208	1	98792	33
28	12 16	47 44	36713	25	63287	37924	26	62076	01211	1	98789	32
29	12 8	47 52	36766	25	63234	37980	27	62020	01214	1	98786	31
30	10 12 0	1 48 0	9.36819	26	10.63181	9.38035	28	10.61965	10.01217	2	9.98783	30
31	11 52	48 8	36871	27	63129	38091	29	61909	01220	2	98780	29
32	11 44	48 16	36924	28	63076	38147	30	61853	01223	2	98777	28
33	11 36	48 24	36976	29	63024	38202	31	61798	01226	2	98774	27
34	11 28	48 32	37028	30	62972	38257	32	61743	01229	2	98771	26
35	10 11 20	1 48 40	9.37081	31	10.62919	9.38313	32	10.61687	10.01232	2	9.98768	25
36	11 12	48 48	37133	32	62867	38368	33	61632	01235	2	98765	24
37	11 4	48 56	37185	32	62815	38423	34	61577	01238	2	98762	23
38	10 56	49 4	37237	33	62763	38479	35	61521	01241	2	98759	22
39	10 48	49 12	37289	34	62711	38534	36	61466	01244	2	98756	21
40	10 10 40	1 49 20	9.37341	35	10.62659	9.38589	37	10.61411	10.01247	2	9.98753	20
41	10 32	49 28	37393	36	62607	38644	38	61356	01250	2	98750	19
42	10 24	49 36	37445	37	62555	38699	39	61301	01254	2	98746	18
43	10 16	49 44	37497	38	62503	38754	40	61246	01257	2	98743	17
44	10 8	49 52	37549	39	62451	38808	41	61192	01260	2	98740	16
45	10 10 0	1 50 0	9.37600	39	10.62400	9.38863	42	10.61137	10.01263	2	9.98737	15
46	9 52	50 8	37652	40	62348	38918	43	61082	01266	2	98734	14
47	9 44	50 16	37703	41	62297	38972	44	61028	01269	2	98731	13
48	9 36	50 24	37755	42	62245	39027	45	60973	01272	2	98728	12
49	9 28	50 32	37806	43	62194	39082	45	60918	01275	2	98725	11
50	10 9 20	1 50 40	9.37858	44	10.62142	9.39136	46	10.60864	10.01278	3	9.98722	10
51	9 12	50 48	37909	45	62091	39190	47	60810	01281	3	98719	9
52	9 4	50 56	37960	46	62040	39245	48	60755	01285	3	98715	8
53	8 56	51 4	38011	47	61989	39299	49	60701	01288	3	98712	7
54	8 48	51 12	38062	47	61938	39353	50	60647	01291	3	98709	6
55	10 8 40	1 51 20	9.38113	48	10.61887	9.39407	51	10.60593	10.01294	3	9.98706	5
56	8 32	51 28	38164	49	61836	39461	52	60539	01297	3	98703	4
57	8 24	51 36	38215	50	61785	39515	53	60485	01300	3	98700	3
58	8 16	51 44	38266	51	61734	39569	54	60431	01303	3	98697	2
59	8 8	51 52	38317	52	61683	39623	55	60377	01306	3	98694	1
60	8 0	52 0	38368	53	61632	39677	56	60323	01310	3	98690	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
103°			A		A	B		B	C		C	76°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	7	13	20	26	33	39	46
	B	7	14	21	28	35	42	49
	C	0	1	1	2	2	2	3

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

8h. 14° — 6h. 165°

M	Hour A.M.	Hour P.M.	A Sine.	Diff.	A Cosecant.	B Tangent.	Diff.	B Cotangent	C Secant.	Diff.	C Cosine.	M
0	10 8 0	1 52 0	9.38368	0	10.61632	9.39677	0	10.60323	10.01310	0	9.98690	60
1	7 52	52 8	38418	1	61582	39731	1	60269	01313	0	98687	59
2	7 44	52 16	38469	2	61531	39785	2	60215	01316	0	98684	58
3	7 36	52 24	38519	2	61481	39838	3	60162	01319	0	98681	57
4	7 28	52 32	38570	3	61430	39892	3	60108	01322	0	98678	56
5	10 7 20	1 52 40	9.38620	4	10.61380	9.39945	4	10.60055	10.01325	0	9.98675	55
6	7 12	52 48	38670	5	61330	39999	5	60001	01329	0	98671	54
7	7 4	52 56	38721	6	61279	40052	6	59948	01332	0	98668	53
8	6 56	53 4	38771	7	61229	40106	7	59894	01335	0	98665	52
9	6 48	53 12	38821	7	61179	40159	8	59841	01338	0	98662	51
10	10 6 40	1 53 20	9.38871	8	10.61129	9.40212	9	10.59788	10.01341	1	9.98659	50
11	6 32	53 28	38921	9	61079	40266	10	59734	01344	1	98656	49
12	6 24	53 36	38971	10	61029	40319	10	59681	01348	1	98652	48
13	6 16	53 44	39021	11	60979	40372	11	59628	01351	1	98649	47
14	6 8	53 52	39071	11	60929	40425	12	59575	01354	1	98646	46
15	10 6 0	1 54 0	9.39121	12	10.60879	9.40478	13	10.59522	10.01357	1	9.98643	45
16	5 52	54 8	39170	13	60830	40531	14	59469	01360	1	98640	44
17	5 44	54 16	39220	14	60780	40584	15	59416	01364	1	98636	43
18	5 36	54 24	39270	15	60730	40636	16	59364	01367	1	98633	42
19	5 28	54 32	39319	15	60681	40689	17	59311	01370	1	98630	41
20	10 5 20	1 54 40	9.39369	16	10.60631	9.40742	17	10.59258	10.01373	1	9.98627	40
21	5 12	54 48	39418	17	60582	40795	18	59205	01377	1	98623	39
22	5 4	54 56	39467	18	60533	40847	19	59153	01380	1	98620	38
23	4 56	55 4	39517	19	60483	40900	20	59100	01383	1	98617	37
24	4 48	55 12	39566	20	60434	40952	21	59048	01386	1	98614	36
25	10 4 40	1 55 20	9.39615	20	10.60385	9.41005	22	10.58995	10.01390	1	9.98610	35
26	4 32	55 28	39664	21	60336	41057	23	58943	01393	1	98607	34
27	4 24	55 36	39713	22	60287	41109	23	58891	01396	1	98604	33
28	4 16	55 44	39762	23	60238	41161	24	58839	01399	2	98601	32
29	4 8	55 52	39811	24	60189	41214	25	58786	01403	2	98597	31
30	10 4 0	1 56 0	9.39860	24	10.60140	9.41266	26	10.58734	10.01406	2	9.98594	30
31	3 52	56 8	39909	25	60091	41318	27	58682	01409	2	98591	29
32	3 44	56 16	39958	26	60042	41370	28	58630	01412	2	98588	28
33	3 36	56 24	40006	27	59994	41422	29	58578	01416	2	98584	27
34	3 28	56 32	40055	28	59945	41474	30	58526	01419	2	98581	26
35	10 3 20	1 56 40	9.40103	29	10.59897	9.41526	30	10.58474	10.01422	2	9.98578	25
36	3 12	56 48	40152	29	59848	41578	31	58422	01426	2	98574	24
37	3 4	56 56	40200	30	59800	41629	32	58371	01429	2	98571	23
38	2 56	57 4	40249	31	59751	41681	33	58319	01432	2	98568	22
39	2 48	57 12	40297	32	59703	41733	34	58267	01435	2	98565	21
40	10 2 40	1 57 20	9.40346	33	10.59654	9.41784	35	10.58216	10.01439	2	9.98561	20
41	2 32	57 28	40394	33	59606	41836	36	58164	01442	2	98558	19
42	2 24	57 36	40442	34	59558	41887	36	58113	01445	2	98555	18
43	2 16	57 44	40490	35	59510	41939	37	58061	01449	2	98551	17
44	2 8	57 52	40538	36	59462	41990	38	58010	01452	2	98548	16
45	10 2 0	1 58 0	9.40586	37	10.59414	9.42041	39	10.57959	10.01455	2	9.98545	15
46	1 52	58 8	40634	37	59366	42093	40	57907	01459	3	98541	14
47	1 44	58 16	40682	38	59318	42144	41	57856	01462	3	98538	13
48	1 36	58 24	40730	39	59270	42195	42	57805	01465	3	98535	12
49	1 28	58 32	40778	40	59222	42246	43	57754	01469	3	98531	11
50	10 1 20	1 58 40	9.40825	41	10.59175	9.42297	43	10.57703	10.01472	3	9.98528	10
51	1 12	58 48	40873	42	59127	42348	44	57652	01475	3	98525	9
52	1 4	58 56	40921	42	59079	42399	45	57601	01479	3	98521	8
53	0 56	59 4	40968	43	59032	42450	46	57550	01482	3	98518	7
54	0 48	59 12	41016	44	58984	42501	47	57499	01485	3	98515	6
55	10 0 40	1 59 20	9.41063	45	10.58937	9.42552	48	10.57448	10.01489	3	9.98511	5
56	0 32	59 28	41111	46	58889	42603	49	57397	01492	3	98508	4
57	0 24	59 36	41158	46	58842	42653	50	57347	01495	3	98505	3
58	0 16	59 44	41205	47	58795	42704	50	57296	01499	3	98501	2
59	0 8	59 52	41252	48	58748	42755	51	57245	01502	3	98498	1
60	0 0	2 0 0	41300	49	58700	42805	52	57195	01506	3	98494	0
M	Hour P.M.	Hour A.M.	Cosine. A	Diff.	Secant. A	Cotangent B	Diff.	Tangent. B	Cosecant. C	Diff.	Sine. C	M

104° — 75°

Seconds of time ……		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	6	12	18	24	31	37	43
	B	7	13	20	26	33	39	46
	C	0	1	1	2	2	2	3

Digitized by Google

TABLE XXVII.

8' G

Log. Sines, Tangents, and Secants.

15° 164°

M	Hour A.M.	Hour P.M.	Sine. A	Diff.	Cosecant. A	Tangent. B	Diff.	Cotangent B	Secant. C	Diff.	Cosine. C	M
0	10 0 0	2 0 0	9.41300	0	10.58700	9.42805	0	10.57195	10.01506	0	9.98494	60
1	9 59 52	0 8	41347	1	58653	42856	1	57144	01509	0	98491	59
2	59 44	0 16	41394	2	58606	42906	2	57094	01512	0	98488	58
3	59 36	0 24	41441	2	58559	42957	2	57043	01516	0	98484	57
4	59 28	0 32	41488	3	58512	43007	3	56993	01519	0	98481	56
5	9 59 20	2 0 40	9.41535	4	10.58465	9.43057	4	10.56943	10.01523	0	9.98477	55
6	59 12	0 48	41582	5	58418	43108	5	56892	01526	0	98474	54
7	59 4	0 56	41628	5	58372	43158	6	56842	01529	0	98471	53
8	58 56	1 4	41675	6	58325	43208	7	56792	01533	0	98467	52
9	58 48	1 12	41722	7	58278	43258	7	56742	01536	1	98464	51
10	9 58 40	2 1 20	9.41768	8	10.58232	9.43308	8	10.56692	10.01540	1	9.98460	50
11	58 32	1 28	41815	8	58185	43358	9	56642	01543	1	98457	49
12	58 24	1 36	41861	9	58139	43408	10	56592	01547	1	98453	48
13	58 16	1 44	41908	10	58092	43458	11	56542	01550	1	98450	47
14	58 8	1 52	41954	11	58046	43508	11	56492	01553	1	98447	46
15	9 58 0	2 2 0	9.42001	11	10.57999	9.43558	12	10.56442	10.01557	1	9.98443	45
16	57 52	2 8	42047	12	57953	43607	13	56393	01560	1	98440	44
17	57 44	2 16	42093	13	57907	43657	14	56343	01564	1	98436	43
18	57 36	2 24	42140	14	57860	43707	15	56293	01567	1	98433	42
19	57 28	2 32	42186	14	57814	43756	16	56244	01571	1	98429	41
20	9 57 20	2 2 40	9.42232	15	10.57768	9.43806	16	10.56194	10.01574	1	9.98426	40
21	57 12	2 48	42278	16	57722	43855	17	56145	01578	1	98422	39
22	57 4	2 56	42324	17	57676	43905	18	56095	01581	1	98419	38
23	56 56	3 4	42370	17	57630	43954	19	56046	01585	1	98415	37
24	56 48	3 12	42416	18	57584	44004	20	55996	01588	1	98412	36
25	9 56 40	2 3 20	9.42461	19	10.57539	9.44053	20	10.55947	10.01591	1	9.98409	35
26	56 32	3 28	42507	20	57493	44102	21	55898	01595	2	98405	34
27	56 24	3 36	42553	21	57447	44151	22	55849	01598	2	98402	33
28	56 16	3 44	42599	21	57401	44201	23	55799	01602	2	98398	32
29	56 8	3 52	42644	22	57356	44250	24	55750	01605	2	98395	31
30	9 56 0	2 4 0	9.42690	23	10.57310	9.44299	25	10.55701	10.01609	2	9.98391	30
31	55 52	4 8	42735	24	57265	44348	25	55652	01612	2	98388	29
32	55 44	4 16	42781	24	57219	44397	26	55603	01616	2	98384	28
33	55 36	4 24	42826	25	57174	44446	27	55554	01619	2	98381	27
34	55 28	4 32	42872	26	57128	44495	28	55505	01623	2	98377	26
35	9 55 20	2 4 40	9.42917	27	10.57083	9.44544	29	10.55456	10.01627	2	9.98373	25
36	55 12	4 48	42962	27	57038	44592	29	55408	01630	2	98370	24
37	55 4	4 56	43008	28	56992	44641	30	55359	01634	2	98366	23
38	54 56	5 4	43053	29	56947	44690	31	55310	01637	2	98363	22
39	54 48	5 12	43098	30	56902	44738	32	55262	01641	2	98359	21
40	9 54 40	2 5 20	9.43143	30	10.56857	9.44787	33	10.55213	10.01644	2	9.98356	20
41	54 32	5 28	43188	31	56812	44836	34	55164	01648	2	98352	19
42	54 24	5 36	43233	32	56767	44884	34	55116	01651	2	98349	18
43	54 16	5 44	43278	33	56722	44933	35	55067	01655	3	98345	17
44	54 8	5 52	43323	33	56677	44981	36	55019	01658	3	98342	16
45	9 54 0	2 6 0	9.43367	34	10.56633	9.45029	37	10.54971	10.01662	3	9.98338	15
46	53 52	6 8	43412	35	56588	45078	38	54922	01666	3	98334	14
47	53 44	6 16	43457	36	56543	45126	38	54874	01669	3	98331	13
48	53 36	6 24	43502	36	56498	45174	39	54826	01673	3	98327	12
49	53 28	6 32	43546	37	56454	45222	40	54778	01676	3	98324	11
50	9 53 20	2 6 40	9.43591	38	10.56409	9.45271	41	10.54729	10.01680	3	9.98320	10
51	53 12	6 48	43635	39	56365	45319	42	54681	01683	3	98317	9
52	53 4	6 56	43680	39	56320	45367	43	54633	01687	3	98313	8
53	52 56	7 4	43724	40	56276	45415	43	54585	01691	3	98309	7
54	52 48	7 12	43769	41	56231	45463	44	54537	01694	3	98306	6
55	9 52 40	2 7 20	9.43813	42	10.56187	9.45511	45	10.54489	10.01698	3	9.98302	5
56	52 32	7 28	43857	43	56143	45559	46	54441	01701	3	98299	4
57	52 24	7 36	43901	43	56099	45606	47	54394	01705	3	98295	3
58	52 16	7 44	43946	44	56054	45654	47	54346	01709	3	98291	2
59	52 8	7 52	43990	45	56010	45702	48	54298	01712	3	98288	1
60	52 0	8 0	44034	46	55966	45750	49	54250	01716	4	98284	0
M	Hour P.M.	Hour A.M.	Cosine. A	Diff.	Secant. A	Cotangent B	Diff.	Tangent. B	Cosecant. C	Diff.	Sine. C	M

115° 74°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	6	11	17	23	28	34	40
	B	6	12	18	25	31	37	43
	C	0	1	1	2	2	3	3

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

9h 6h

16° A A B B C C 163°

M	Hour A.M.	Hour P.M.	Sine.	Diff	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	9 52 0	2 8 0	9.44034	0	10.55966	9.45750	0	10.54250	10.01716	0	9.98284	60
1	51 52	8 8	44078	1	55922	45797	1	54203	01719	0	98281	59
2	51 44	8 16	44122	1	55878	45845	2	54155	01723	0	98277	58
3	51 36	8 24	44166	2	55834	45892	2	54108	01727	0	98273	57
4	51 28	8 32	44210	3	55790	45940	3	54060	01730	0	98270	56
5	9 51 20	2 8 40	9.44253	4	10.55747	9.45987	4	10.54013	10.01734	0	9.98266	55
6	51 12	8 48	44297	4	55703	46035	5	53965	01738	0	98262	54
7	51 4	8 56	44341	5	55659	46082	5	53918	01741	0	98259	53
8	50 56	9 4	44385	6	55615	46130	6	53870	01745	0	98255	52
9	50 48	9 12	44428	6	55572	46177	7	53823	01749	1	98251	51
10	9 50 40	2 9 20	9.44472	7	10.55528	9.46224	8	10.53776	10.01752	1	9.98248	50
11	50 32	9 28	44516	8	55484	46271	9	53729	01756	1	98244	49
12	50 24	9 36	44559	9	55441	46319	9	53681	01760	1	98240	48
13	50 16	9 44	44602	9	55398	46366	10	53634	01763	1	98237	47
14	50 8	9 52	44646	10	55354	46413	11	53587	01767	1	98233	46
15	9 50 0	2 10 0	9.44689	11	10.55311	9.46460	12	10.53540	10.01771	1	9.98229	45
16	49 52	10 8	44733	11	55267	46507	12	53493	01774	1	98226	44
17	49 44	10 16	44776	12	55224	46554	13	53446	01778	1	98222	43
18	49 36	10 24	44819	13	55181	46601	14	53399	01782	1	98218	42
19	49 28	10 32	44862	14	55138	46648	15	53352	01785	1	98215	41
20	9 49 20	2 10 40	9.44905	14	10.55095	9.46694	15	10.53306	10.01789	1	9.98211	40
21	49 12	10 48	44948	15	55052	46741	16	53259	01793	1	98207	39
22	49 4	10 56	44992	16	55008	46788	17	53212	01796	1	98204	38
23	48 56	11 4	45035	16	54965	46835	18	53165	01800	1	98200	37
24	48 48	11 12	45077	17	54923	46881	19	53119	01804	1	98196	36
25	9 48 40	2 11 20	9.45120	18	10.54880	9.46928	19	10.53072	10.01808	2	9.98192	35
26	48 32	11 28	45163	18	54837	46975	20	53025	01811	2	98189	34
27	48 24	11 36	45206	19	54794	47021	21	52979	01815	2	98185	33
28	48 16	11 44	45249	20	54751	47068	22	52932	01819	2	98181	32
29	48 8	11 52	45292	21	54708	47114	22	52886	01823	2	98177	31
30	9 48 0	2 12 0	9.45334	21	10.54666	9.47160	23	10.52840	10.01826	2	9.98174	30
31	47 52	12 8	45377	22	54623	47207	24	52793	01830	2	98170	29
32	47 44	12 16	45419	23	54581	47253	25	52747	01834	2	98166	28
33	47 36	12 24	45462	23	54538	47299	26	52701	01838	2	98162	27
34	47 28	12 32	45504	24	54496	47346	26	52654	01841	2	98159	26
35	9 47 20	2 12 40	9.45547	25	10.54453	9.47392	27	10.52608	10.01845	2	9.98155	25
36	47 12	12 48	45589	26	54411	47438	28	52562	01849	2	98151	24
37	47 4	12 56	45632	26	54368	47484	29	52516	01853	2	98147	23
38	46 56	13 4	45674	27	54326	47530	29	52470	01856	2	98144	22
39	46 48	13 12	45716	28	54284	47576	30	52424	01860	2	98140	21
40	9 46 40	2 13 20	9.45758	28	10.54242	9.47622	31	10.52378	10.01864	2	9.98136	20
41	46 32	13 28	45801	29	54199	47668	32	52332	01868	3	98132	19
42	46 24	13 36	45843	30	54157	47714	32	52286	01871	3	98129	18
43	46 16	13 44	45885	31	54115	47760	33	52240	01875	3	98125	17
44	46 8	13 52	45927	31	54073	47806	34	52194	01879	3	98121	16
45	9 46 0	2 14 0	9.45969	32	10.54031	9.47852	35	10.52148	10.01883	3	9.98117	15
46	45 52	14 8	46011	33	53989	47897	36	52103	01887	3	98113	14
47	45 44	14 16	46053	33	53947	47943	36	52057	01890	3	98110	13
48	45 36	14 24	46095	34	53905	47989	37	52011	01894	3	98106	12
49	45 28	14 32	46136	35	53864	48035	38	51965	01898	3	98102	11
50	9 45 20	2 14 40	9.46178	36	10.53822	9.48080	39	10.51920	10.01902	3	9.98098	10
51	45 12	14 48	46220	36	53780	48126	39	51874	01906	3	98094	9
52	45 4	14 56	46262	37	53738	48171	40	51829	01910	3	98090	8
53	44 56	15 4	46303	38	53697	48217	41	51783	01913	3	98087	7
54	44 48	15 12	46345	38	53655	48262	42	51738	01917	3	98083	6
55	9 44 40	2 15 20	9.46386	39	10.53614	9.48307	43	10.51693	10.01921	3	9.98079	5
56	44 32	15 28	46428	40	53572	48353	43	51647	01925	3	98075	4
57	44 24	15 36	46469	41	53531	48398	44	51602	01929	4	98071	3
58	44 16	15 44	46511	41	53489	48443	45	51557	01933	4	98067	2
59	44 8	15 52	46552	42	53448	48489	46	51511	01937	4	98063	1
60	44 0	16 0	46594	43	53406	48534	46	51466	01940	4	98060	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

106° A A B B C C 73°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols	A	5	11	16	21	27	32	37
	B	6	12	17	23	29	35	41
	C	0	1	1	2	2	3	3

Digitized by Google

TABLE XXVII.

S′. Log. Sines, Tangents, and Secants. G′.

17° A A B B C C 162°

M	Hour A.M.	Hour P.M.	Sine.	Diff	Cosecant.	Tangent.	Diff	Cotangent	Secant.	Diff.	Cosine.	M
0	9 44 0	2 16 0	9.46594	0	10.53406	9.48534	0	10.51466	10.01940	0	9.98060	60
1	43 52	16 8	46635	1	53365	48579	1	51421	01944	0	98056	59
2	43 44	16 16	46676	1	53324	48624	1	51376	01948	0	98052	58
3	43 36	16 24	46717	2	53283	48669	2	51331	01952	0	98048	57
4	43 28	16 32	46758	3	53242	48714	3	51286	01956	0	98044	56
5	9 43 20	2 16 40	9.46800	3	10.53200	9.48759	4	10.51241	10.01960	0	9.98040	55
6	43 12	16 48	46841	4	53159	48804	4	51196	01964	0	98036	54
7	43 4	16 56	46882	5	53118	48849	5	51151	01968	0	98032	53
8	42 56	17 4	46923	5	53077	48894	6	51106	01971	1	98029	52
9	42 48	17 12	46964	6	53036	48939	7	51061	01975	1	98025	51
10	9 42 40	2 17 20	9.47005	7	10.52995	9.48984	7	10.51016	10.01979	1	9.98021	50
11	42 32	17 28	47045	7	52955	49029	8	50971	01983	1	98017	49
12	42 24	17 36	47086	8	52914	49073	9	50927	01987	1	98013	48
13	42 16	17 44	47127	9	52873	49118	10	50882	01991	1	98009	47
14	42 8	17 52	47168	9	52832	49163	10	50837	01995	1	98005	46
15	9 42 0	2 18 0	9.47209	10	10.52791	9.49207	11	10.50793	10.01999	1	9.98001	45
16	41 52	18 8	47249	11	52751	49252	12	50748	02003	1	97997	44
17	41 44	18 16	47290	11	52710	49296	12	50704	02007	1	97993	43
18	41 36	18 24	47330	12	52670	49341	13	50659	02011	1	97989	42
19	41 28	18 32	47371	13	52629	49385	14	50615	02014	1	97986	41
20	9 41 20	2 18 40	9.47411	13	10.52589	9.49430	15	10.50570	10.02018	1	9.97982	40
21	41 12	18 48	47452	14	52548	49474	15	50526	02022	1	97978	39
22	41 4	18 56	47492	15	52508	49519	16	50481	02026	1	97974	38
23	40 56	19 4	47533	15	52467	49563	17	50437	02030	2	97970	37
24	40 48	19 12	47573	16	52427	49607	18	50393	02034	2	97966	36
25	9 40 40	2 19 20	9.47613	17	10.52387	9.49652	18	10.50348	10.02038	2	9.97962	35
26	40 32	19 28	47654	17	52346	49696	19	50304	02042	2	97958	34
27	40 24	19 36	47694	18	52306	49740	20	50260	02046	2	97954	33
28	40 16	19 44	47734	19	52266	49784	21	50216	02050	2	97950	32
29	40 8	19 52	47774	19	52226	49828	21	50172	02054	2	97946	31
30	9 40 0	2 20 0	9.47814	20	10.52186	9.49872	22	10.50128	10.02058	2	9.97942	30
31	39 52	20 8	47854	21	52146	49916	23	50084	02062	2	97938	29
32	39 44	20 16	47894	21	52106	49960	24	50040	02066	2	97934	28
33	39 36	20 24	47934	22	52066	50004	24	49996	02070	2	97930	27
34	39 28	20 32	47974	23	52026	50048	25	49952	02074	2	97926	26
35	9 39 20	2 20 40	9.48014	23	10.51986	9.50092	26	10.49908	10.02078	2	9.97922	25
36	39 12	20 48	48054	24	51946	50136	26	49864	02082	2	97918	24
37	39 4	20 56	48094	25	51906	50180	27	49820	02086	2	97914	23
38	38 56	21 4	48133	25	51867	50223	28	49777	02090	3	97910	22
39	38 48	21 12	48173	26	51827	50267	29	49733	02094	3	97906	21
40	9 38 40	2 21 20	9.48213	27	10.51787	9.50311	29	10.49689	10.02098	3	9.97902	20
41	38 32	21 28	48252	27	51748	50355	30	49645	02102	3	97898	19
42	38 24	21 36	48292	28	51708	50398	31	49602	02106	3	97894	18
43	38 16	21 44	48332	29	51668	50442	32	49558	02110	3	97890	17
44	38 8	21 52	48371	29	51629	50485	32	49515	02114	3	97886	16
45	9 38 0	2 22 0	9.48411	30	10.51589	9.50529	33	10.49471	10.02118	3	9.97882	15
46	37 52	22 8	48450	31	51550	50572	34	49428	02122	3	97878	14
47	37 44	22 16	48490	31	51510	50616	35	49384	02126	3	97874	13
48	37 36	22 24	48529	32	51471	50659	35	49341	02130	3	97870	12
49	37 28	22 32	48568	33	51432	50703	36	49297	02134	3	97866	11
50	9 37 20	2 22 40	9.48607	33	10.51393	9.50746	37	10.49254	10.02139	3	9.97861	10
51	37 12	22 48	48647	34	51353	50789	37	49211	02143	3	97857	9
52	37 4	22 56	48686	35	51314	50833	38	49167	02147	3	97853	8
53	36 56	23 4	48725	35	51275	50876	39	49124	02151	4	97849	7
54	36 48	23 12	48764	36	51236	50919	40	49081	02155	4	97845	6
55	9 36 40	2 23 20	9.48803	37	10.51197	9.50962	40	10.49038	10.02159	4	9.97841	5
56	36 32	23 28	48842	37	51158	51005	41	48995	02163	4	97837	4
57	36 24	23 36	48881	38	51119	51048	42	48952	02167	4	97833	3
58	36 16	23 44	48920	39	51080	51092	43	48908	02171	4	97829	2
59	36 8	23 52	48959	39	51041	51135	43	48865	02175	4	97825	1
60	36 0	24 0	48998	40	51002	51178	44	48822	02179	4	97821	0
M	Hour P.M.	Hour A.M.	Cosine	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

107° A A B B C C 72°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	5	10	15	20	25	30	35
	B	6	11	17	22	28	33	39
	C	0	1	1	2	2	3	3

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

8'. 6'

18° A A B B C C 161°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	9 36 0	2 24 0	9.48998	0	10.51002	9.51178	0	10.48822	10.02179	0	9.97821	60
1	35 52	24 8	49037	1	50963	51221	1	48779	02183	0	97817	59
2	35 44	24 16	49076	1	50924	51264	1	48736	02188	0	97812	58
3	35 36	24 24	49115	2	50885	51306	2	48694	02192	0	97808	57
4	35 28	24 32	49153	3	50847	51349	3	48651	02196	0	97804	56
5	9 35 20	2 24 40	9.49192	3	10.50808	9.51392	3	10.48608	10.02200	0	9.97800	55
6	35 12	24 48	49231	4	50769	51435	4	48565	02204	0	97796	54
7	35 4	24 56	49269	4	50731	51478	5	48522	02208	0	97792	53
8	34 56	25 4	49308	5	50692	51520	6	48480	02212	1	97788	52
9	34 48	25 12	49347	6	50653	51563	6	48437	02216	1	97784	51
10	9 34 40	2 25 20	9.49385	6	10.50615	9.51606	7	10.48394	10.02221	1	9.97779	50
11	34 32	25 28	49424	7	50576	51648	8	48352	02225	1	97775	49
12	34 24	25 36	49462	8	50538	51691	8	48309	02229	1	97771	48
13	34 16	25 44	49500	8	50500	51734	9	48266	02233	1	97767	47
14	34 8	25 52	49539	9	50461	51776	10	48224	02237	1	97763	46
15	9 34 0	2 26 0	9.49577	9	10.50423	9.51819	10	10.48181	10.02241	1	9.97759	45
16	33 52	26 8	49615	10	50385	51861	11	48139	02246	1	97754	44
17	33 44	26 16	49654	11	50346	51903	12	48097	02250	1	97750	43
18	33 36	26 24	49692	11	50308	51946	13	48054	02254	1	97746	42
19	33 28	26 32	49730	12	50270	51988	13	48012	02258	1	97742	41
20	9 33 20	2 26 40	9.49768	13	10.50232	9.52031	14	10.47969	10.02262	1	9.97738	40
21	33 12	26 48	49806	13	50194	52073	15	47927	02266	1	97734	39
22	33 4	26 56	49844	14	50156	52115	15	47885	02271	2	97729	38
23	32 56	27 4	49882	14	50118	52157	16	47843	02275	2	97725	37
24	32 48	27 12	49920	15	50080	52200	17	47800	02279	2	97721	36
25	9 32 40	2 27 20	9.49958	16	10.50042	9.52242	17	10.47758	10.02283	2	9.97717	35
26	32 32	27 28	49996	16	50004	52284	18	47716	02287	2	97713	34
27	32 24	27 36	50034	17	49966	52326	19	47674	02292	2	97708	33
28	32 16	27 44	50072	18	49928	52368	20	47632	02296	2	97704	32
29	32 8	27 52	50110	18	49890	52410	20	47590	02300	2	97700	31
30	9 32 0	2 28 0	9.50148	19	10.49852	9.52452	21	10.47548	10.02304	2	9.97696	30
31	31 52	28 8	50185	20	49815	52494	22	47506	02309	2	97691	29
32	31 44	28 16	50223	20	49777	52536	22	47464	02313	2	97687	28
33	31 36	28 24	50261	21	49739	52578	23	47422	02317	2	97683	27
34	31 28	28 32	50298	21	49702	52620	24	47380	02321	2	97679	26
35	9 31 20	2 28 40	9.50336	22	10.49664	9.52661	24	10.47339	10.02326	2	9.97674	25
36	31 12	28 48	50374	23	49626	52703	25	47297	02330	3	97670	24
37	31 4	28 56	50411	23	49589	52745	26	47255	02334	3	97666	23
38	30 56	29 4	50449	24	49551	52787	27	47213	02338	3	97662	22
39	30 48	29 12	50486	25	49514	52829	27	47171	02343	3	97657	21
40	9 30 40	2 29 20	9.50523	25	10.49477	9.52870	28	10.47130	10.02347	3	9.97653	20
41	30 32	29 28	50561	26	49439	52912	29	47088	02351	3	97649	19
42	30 24	29 36	50598	26	49402	52953	29	47047	02355	3	97645	18
43	30 16	29 44	50635	27	49365	52995	30	47005	02360	3	97640	17
44	30 8	29 52	50673	28	49327	53037	31	46963	02364	3	97636	16
45	9 30 0	2 30 0	9.50710	28	10.49290	9.53078	31	10.46922	10.02368	3	9.97632	15
46	29 52	30 8	50747	29	49253	53120	32	46880	02372	3	97628	14
47	29 44	30 16	50784	30	49216	53161	33	46839	02377	3	97623	13
48	29 36	30 24	50821	30	49179	53202	34	46798	02381	3	97619	12
49	29 28	30 32	50858	31	49142	53244	34	46756	02385	3	97615	11
50	9 29 20	2 30 40	9.50896	31	10.49104	9.53285	35	10.46715	10.02390	4	9.97610	10
51	29 12	30 48	50933	32	49067	53327	36	46673	02394	4	97606	9
52	29 4	30 56	50970	33	49030	53368	36	46632	02398	4	97602	8
53	28 56	31 4	51007	33	48993	53409	37	46591	02403	4	97597	7
54	28 48	31 12	51043	34	48957	53450	38	46550	02407	4	97593	6
55	9 28 40	2 31 20	9.51080	35	10.48920	9.53492	38	10.46508	10.02411	4	9.97589	5
56	28 32	31 28	51117	35	48883	53533	39	46467	02416	4	97584	4
57	28 24	31 36	51154	36	48846	53574	40	46426	02420	4	97580	3
58	28 16	31 44	51191	37	48809	53615	41	46385	02424	4	97576	2
59	28 8	31 52	51227	37	48773	53656	41	46344	02429	4	97571	1
60	28 0	32 0	51264	38	48736	53697	42	46303	02433	4	97567	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

108° A A B B C C 71°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	5	9	14	19	24	28	33
	B	5	10	16	21	26	31	37
	C	1	1	2	2	3	3	4

Digitized by Google

TABLE XXVII.

S′. **Log Sines, Tangents, and Secants.** G′.

19°			A		A	B		B	C		C	160°
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	9 28 0	2 32 0	9.51264	0	10.48736	9.53697	0	10.46303	10.02433	0	9.97567	60
1	27 52	32 8	51301	1	48699	53738	1	46262	02437	0	97563	59
2	27 44	32 16	51338	1	48662	53779	1	46221	02442	0	97558	58
3	27 36	32 24	51374	2	48626	53820	2	46180	02446	0	97554	57
4	27 28	32 32	51411	2	48589	53861	3	46139	02450	0	97550	56
5	9 27 20	2 32 40	9.51447	3	10.48553	9.53902	3	10.46098	10.02455	0	9.97545	55
6	27 12	32 48	51484	4	48516	53943	4	46057	02459	0	97541	54
7	27 4	32 56	51520	4	48480	53984	5	46016	02464	1	97536	53
8	26 56	33 4	51557	5	48443	54025	5	45975	02468	1	97532	52
9	26 48	33 12	51593	5	48407	54065	6	45935	02472	1	97528	51
10	9 26 40	2 33 20	9.51629	6	10.48371	9.54106	7	10.45894	10.02477	1	9.97523	50
11	26 32	33 28	51666	7	48334	54147	7	45853	02481	1	97519	49
12	26 24	33 36	51702	7	48298	54187	8	45813	02485	1	97515	48
13	26 16	33 44	51738	8	48262	54228	9	45772	02490	1	97510	47
14	26 8	33 52	51774	8	48226	54269	9	45731	02494	1	97506	46
15	9 26 0	2 34 0	9.51811	9	10.48189	9.54309	10	10.45691	10.02499	1	9.97501	45
16	25 52	34 8	51847	10	48153	54350	11	45650	02503	1	97497	44
17	25 44	34 16	51883	10	48117	54390	11	45610	02508	1	97492	43
18	25 36	34 24	51919	11	48081	54431	12	45569	02512	1	97488	42
19	25 28	34 32	51955	11	48045	54471	13	45529	02516	1	97484	41
20	9 25 20	2 34 40	9.51991	12	10.48009	9.54512	13	10.45488	10.02521	1	9.97479	40
21	25 12	34 48	52027	12	47973	54552	14	45448	02525	2	97475	39
22	25 4	34 56	52063	13	47937	54593	15	45407	02530	2	97470	38
23	24 56	35 4	52099	14	47901	54633	15	45367	02534	2	97466	37
24	24 48	35 12	52135	14	47865	54673	16	45327	02539	2	97461	36
25	9 24 40	2 35 20	9.52171	15	10.47829	9.54714	17	10.45286	10.02543	2	9.97457	35
26	24 32	35 28	52207	15	47793	54754	17	45246	02547	2	97453	34
27	24 24	35 36	52242	16	47758	54794	18	45206	02552	2	97448	33
28	24 16	35 44	52278	17	47722	54835	19	45165	02556	2	97444	32
29	24 8	35 52	52314	17	47686	54875	19	45125	02561	2	97439	31
30	9 24 0	2 36 0	9.52350	18	10.47650	9.54915	20	10.45085	10.02565	2	9.97435	30
31	23 52	36 8	52385	18	47615	54955	21	45045	02570	2	97430	29
32	23 44	36 16	52421	19	47579	54995	21	45005	02574	2	97426	28
33	23 36	36 24	52456	20	47544	55035	22	44965	02579	2	97421	27
34	23 28	36 32	52492	20	47508	55075	23	44925	02583	3	97417	26
35	9 23 20	2 36 40	9.52527	21	10.47473	9.55115	23	10.44885	10.02588	3	9.97412	25
36	23 12	36 48	52563	21	47437	55155	24	44845	02592	3	97408	24
37	23 4	36 56	52598	22	47402	55195	25	44805	02597	3	97403	23
38	22 56	37 4	52634	23	47366	55235	25	44765	02601	3	97399	22
39	22 48	37 12	52669	23	47331	55275	26	44725	02606	3	97394	21
40	9 22 40	2 37 20	9.52705	24	10.47295	9.55315	27	10.44685	10.02610	3	9.97390	20
41	22 32	37 28	52740	24	47260	55355	27	44645	02615	3	97385	19
42	22 24	37 36	52775	25	47225	55395	28	44605	02619	3	97381	18
43	22 16	37 44	52811	26	47189	55434	29	44566	02624	3	97376	17
44	22 8	37 52	52846	26	47154	55474	29	44526	02628	3	97372	16
45	9 22 0	2 38 0	9.52881	27	10.47119	9.55514	30	10.44486	10.02633	3	9.97367	15
46	21 52	38 8	52916	27	47084	55554	31	44446	02637	3	97363	14
47	21 44	38 16	52951	28	47049	55593	31	44407	02642	3	97358	13
48	21 36	38 24	52986	29	47014	55633	32	44367	02647	4	97353	12
49	21 28	38 32	53021	29	46979	55673	33	44327	02651	4	97349	11
50	9 21 20	2 38 40	9.53056	30	10.46944	9.55712	33	10.44288	10.02656	4	9.97344	10
51	21 12	38 48	53092	30	46908	55752	34	44248	02660	4	97340	9
52	21 4	38 56	53126	31	46874	55791	35	44209	02665	4	97335	8
53	20 56	39 4	53161	32	46839	55831	35	44169	02669	4	97331	7
54	20 48	39 12	53196	32	46804	55870	36	44130	02674	4	97326	6
55	9 20 40	2 39 20	9.53231	33	10.46769	9.55910	37	10.44090	10.02678	4	9.97322	5
56	20 32	39 28	53266	33	46734	55949	37	44051	02683	4	97317	4
57	20 24	39 36	53301	34	46699	55989	38	44011	02688	4	97312	3
58	20 16	39 44	53336	34	46664	56028	39	43972	02692	4	97308	2
59	20 8	39 52	53370	35	46630	56067	39	43933	02697	4	97303	1
60	20 0	40 0	53405	36	46595	56107	40	43893	02701	4	97299	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
109°			A		A	B		B	C		C	70°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	4	9	13	18	22	27	31
	B	5	10	15	20	25	30	35
	C	1	1	2	2	3	3	4

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

8ʰ. 20° — 159° 6ʰ.

			A		A	B		B	C		C	
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	9 20 0	2 40 0	9.53405	0	10.46595	9.56107	0	10.43893	10.02701	0	9.97299	60
1	19 52	40 8	53440	1	46560	56146	1	43854	02706	0	97294	59
2	19 44	40 16	53475	1	46525	56185	1	43815	02711	0	97289	58
3	19 36	40 24	53509	2	46491	56224	2	43776	02715	0	97285	57
4	19 28	40 32	53544	2	46456	56264	3	43736	02720	0	97280	56
5	9 19 20	2 40 40	9.53578	3	10.46422	9.56303	3	10.43697	10.02724	0	9.97276	55
6	19 12	40 48	53613	3	46387	56342	4	43658	02729	0	97271	54
7	19 4	40 56	53647	4	46353	56381	4	43619	02734	1	97266	53
8	18 56	41 4	53682	5	46318	56420	5	43580	02738	1	97262	52
9	18 48	41 12	53716	5	46284	56459	6	43541	02743	1	97257	51
10	9 18 40	2 41 20	9.53751	6	10.46249	9.56498	6	10.43502	10.02748	1	9.97252	50
11	18 32	41 28	53785	6	46215	56537	7	43463	02752	1	97248	49
12	18 24	41 36	53819	7	46181	56576	8	43424	02757	1	97243	48
13	18 16	41 44	53854	7	46146	56615	8	43385	02762	1	97238	47
14	18 8	41 52	53888	8	46112	56654	9	43346	02766	1	97234	46
15	9 18 0	2 42 0	9.53922	8	10.46078	9.56693	10	10.43307	10.02771	1	9.97229	45
16	17 52	42 8	53957	9	46043	56732	10	43268	02776	1	97224	44
17	17 44	42 16	53991	10	46009	56771	11	43229	02780	1	97220	43
18	17 36	42 24	54025	10	45975	56810	12	43190	02785	1	97215	42
19	17 28	42 32	54059	11	45941	56849	12	43151	02790	1	97210	41
20	9 17 20	2 42 40	9.54093	11	10.45907	9.56887	13	10.43113	10.02794	2	9.97206	40
21	17 12	42 48	54127	12	45873	56926	13	43074	02799	2	97201	39
22	17 4	42 56	54161	12	45839	56965	14	43035	02804	2	97196	38
23	16 56	43 4	54195	13	45805	57004	15	42996	02808	2	97192	37
24	16 48	43 12	54229	14	45771	57042	15	42958	02813	2	97187	36
25	9 16 40	2 43 20	9.54263	14	10.45737	9.57081	16	10.42919	10.02818	2	9.97182	35
26	16 32	43 28	54297	15	45703	57120	17	42880	02822	2	97178	34
27	16 24	43 36	54331	15	45669	57158	17	42842	02827	2	97173	33
28	16 16	43 44	54365	16	45635	57197	18	42803	02832	2	97168	32
29	16 8	43 52	54399	16	45601	57235	19	42765	02837	2	97163	31
30	9 16 0	2 44 0	9.54433	17	10.45567	9.57274	19	10.42726	10.02841	2	9.97159	30
31	15 52	44 8	54466	17	45534	57312	20	42688	02846	2	97154	29
32	15 44	44 16	54500	18	45500	57351	21	42649	02851	3	97149	28
33	15 36	44 24	54534	19	45466	57389	21	42611	02855	3	97145	27
34	15 28	44 32	54567	19	45433	57428	22	42572	02860	3	97140	26
35	9 15 20	2 44 40	9.54601	20	10.45399	9.57466	22	10.42534	10.02865	3	9.97135	25
36	15 12	44 48	54635	20	45365	57504	23	42496	02870	3	97130	24
37	15 4	44 56	54668	21	45332	57543	24	42457	02874	3	97126	23
38	14 56	45 4	54702	21	45298	57581	24	42419	02879	3	97121	22
39	14 48	45 12	54735	22	45265	57619	25	42381	02884	3	97116	21
40	9 14 40	2 45 20	9.54769	23	10.45231	9.57658	26	10.42342	10.02889	3	9.97111	20
41	14 32	45 28	54802	23	45198	57696	26	42304	02893	3	97107	19
42	14 24	45 36	54836	24	45164	57734	27	42266	02898	3	97102	18
43	14 16	45 44	54869	24	45131	57772	28	42228	02903	3	97097	17
44	14 8	45 52	54903	25	45097	57810	28	42190	02908	3	97092	16
45	9 14 0	2 46 0	9.54936	25	10.45064	9.57849	29	10.42151	" 02913	4	9.97087	15
46	13 52	46 8	54969	26	45031	57887	30	42113	02917	4	97083	14
47	13 44	46 16	55003	26	44997	57925	30	42075	02922	4	97078	13
48	13 36	46 24	55036	27	44964	57963	31	42037	02927	4	97073	12
49	13 28	46 32	55069	28	44931	58001	31	41999	02932	4	97068	11
50	9 13 20	2 46 40	9.55102	28	10.44898	9.58039	32	10.41961	10.02937	4	9.97063	10
51	13 12	46 48	55136	29	44864	58077	33	41923	02941	4	97059	9
52	13 4	46 56	55169	29	44831	58115	33	41885	02946	4	97054	8
53	12 56	47 4	55202	30	44798	58153	34	41847	02951	4	97049	7
54	12 48	47 12	55235	30	44765	58191	35	41809	02956	4	97044	6
55	9 12 40	2 47 20	9.55268	31	10.44732	9.58229	35	10.41771	10.02961	4	9.97039	5
56	12 32	47 28	55301	32	44699	58267	36	41733	02965	4	97035	4
57	12 24	47 36	55334	32	44666	58304	37	41696	02970	4	97030	3
58	12 16	47 44	55367	33	44633	58342	37	41658	02975	5	97025	2
59	12 8	47 52	55400	33	44600	58380	38	41620	02980	5	97020	1
60	12 0	48 0	55433	34	44567	58418	39	41582	02985	5	97015	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
110°			A		A	B		B	C		C	69°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	4	8	13	17	21	25	30
	B	5	10	14	19	24	29	34
	C	1	1	2	2	3	4	4

Digitized by Google

TABLE XXVII.

8h. **Log. Sines, Tangents, and Secants.** 6h

21° | A | A | B | B | C | C | 158°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	9 12 0	2 48 0	9.55433	0	10.44567	9.58418	0	10.41582	10.02985	0	9.97015	60
1	11 52	48 8	55466	1	44534	58455	1	41545	02990	0	97010	59
2	11 44	48 16	55499	1	44501	58493	1	41507	02995	0	97005	58
3	11 36	48 24	55532	2	44468	58531	2	41469	02999	0	97001	57
4	11 28	48 32	55564	2	44436	58569	2	41431	03004	0	96996	56
5	9 11 20	2 48 40	9.55597	3	10.44403	9.58606	3	10.41394	10.03009	0	9.96991	55
6	11 12	48 48	55630	3	44370	58644	4	41356	03014	0	96986	54
7	11 4	48 56	55663	4	44337	58681	4	41319	03019	1	96981	53
8	10 56	49 4	55695	4	44305	58719	5	41281	03024	1	96976	52
9	10 48	49 12	55728	5	44272	58757	6	41243	03029	1	96971	51
10	9 10 40	2 49 20	9.55761	5	10.44239	9.58794	6	10.41206	10.03034	1	9.96966	50
11	10 32	49 28	55793	6	44207	58832	7	41168	03038	1	96962	49
12	10 24	49 36	55826	6	44174	58869	7	41131	03043	1	96957	48
13	10 16	49 44	55858	7	44142	58907	8	41093	03048	1	96952	47
14	10 8	49 52	55891	7	44109	58944	9	41056	03053	1	96947	46
15	9 10 0	2 50 0	9.55923	8	10.44077	9.58981	9	10.41019	10.03058	1	9.96942	45
16	9 52	50 8	55956	9	44044	59019	10	40981	03063	1	96937	44
17	9 44	50 16	55988	9	44012	59056	10	40944	03068	1	96932	43
18	9 36	50 24	56021	10	43979	59094	11	40906	03073	[illegible]	96927	42
19	9 28	50 32	56053	10	43947	59131	12	40869	03078	2	96922	41
20	9 9 20	2 50 40	9.56085	11	10.43915	9.59168	12	10.40832	10.03083	2	9.96917	40
21	9 12	50 48	56118	11	43882	59205	13	40795	03088	2	96912	39
22	9 4	50 56	56150	12	43850	59243	14	40757	03093	2	96907	38
23	8 56	51 4	56182	12	43818	59280	14	40720	03097	2	96903	37
24	8 48	51 12	56215	13	43785	59317	15	40683	03102	2	96898	36
25	9 8 40	2 51 20	9.56247	13	10.43753	9.59354	15	10.40646	10.03107	2	9.96893	35
26	8 32	51 28	56279	14	43721	59391	16	40609	03112	2	96888	34
27	8 24	51 36	56311	14	43689	59429	17	40571	03117	2	96883	33
28	8 16	51 44	56343	15	43657	59466	17	40534	03122	2	96878	32
29	8 8	51 52	56375	16	43625	59503	18	40497	03127	2	96873	31
30	9 8 0	2 52 0	9.56408	16	10.43592	9.59540	19	10.40460	10.03132	2	9.96868	30
31	7 52	52 8	56440	17	43560	59577	19	40423	03137	3	96863	29
32	7 44	52 16	56472	17	43528	59614	20	40386	03142	3	96858	28
33	7 36	52 24	56504	18	43496	59651	20	40349	03147	3	96853	27
34	7 28	52 32	56536	18	43464	59688	21	40312	03152	3	96848	26
35	9 7 20	2 52 40	9.56568	19	10.43432	9.59725	22	10.40275	10.03157	3	9.96843	25
36	7 12	52 48	56599	19	43401	59762	22	40238	03162	3	96838	24
37	7 4	52 56	56631	20	43369	59799	23	40201	03167	3	96833	23
38	6 56	53 4	56663	20	43337	59835	23	40165	03172	3	96828	22
39	6 48	53 12	56695	21	43305	59872	24	40128	03177	3	96823	21
40	9 6 40	2 53 20	9.56727	21	10.43273	9.59909	25	10.40091	10.03182	3	9.96818	20
41	6 32	53 28	56759	22	43241	59946	25	40054	03187	3	96813	19
42	6 24	53 36	56790	22	43210	59983	26	40017	03192	3	96808	18
43	6 16	53 44	56822	23	43178	60019	27	39981	03197	4	96803	17
44	6 8	53 52	56854	24	43146	60056	27	39944	03202	4	96798	16
45	9 6 0	2 54 0	9.56886	24	10.43114	9.60093	28	10.39907	10.03207	4	9.96793	15
46	5 52	54 8	56917	25	43083	60130	28	39870	03212	4	96788	14
47	5 44	54 16	56949	25	43051	60166	29	39834	03217	4	96783	13
48	5 36	54 24	56980	26	43020	60203	30	39797	03222	4	.96778	12
49	5 28	54 32	57012	26	42988	60240	30	39760	03228	4	96772	11
50	9 5 20	2 54 40	9.57044	27	10.42956	9.60276	31	10.39724	10.03233	4	9.96767	10
51	5 12	54 48	57075	27	42925	60313	31	39687	03238	4	96762	9
52	5 4	54 56	57107	28	42893	60349	32	39651	03243	4	96757	8
53	4 56	55 4	57138	28	42862	60386	33	39614	03248	4	96752	7
54	4 48	55 12	57169	29	42831	60422	33	39578	03253	4	96747	6
55	9 4 40	2 55 20	9.57201	29	10.42799	9.60459	34	10.39541	10.03258	5	9.96742	5
56	4 32	55 28	57232	30	42768	60495	35	39505	03263	5	96737	4
57	4 24	55 36	57264	30	42736	60532	35	39468	03268	5	96732	3
58	4 16	55 44	57295	31	42705	60568	36	39432	03273	5	96727	2
59	4 8	55 52	57326	32	42674	60605	36	39395	03278	5	96722	1
60	4 0	56 0	57358	32	42642	60641	37	39359	03283	5	96717	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

111° | A | A | B | B | C | C | 68°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	4	8	12	16	20	24	28
	B	5	9	14	19	23	28	32
	C	1	1	2	2	3	4	4

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

S'. G'.

22° | A | A | B | B | C | C | 157°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M
0	9 4 0	2 56 0	9.57358	0	10.42642	9.60641	0	10.39359	10.03283	0	9.96717	60
1	3 52	56 8	57389	1	42611	60677	1	39323	03289	0	96711	59
2	3 44	56 16	57420	1	42580	60714	1	39286	03294	0	96706	58
3	3 36	56 24	57451	2	42549	60750	2	39250	03299	0	96701	57
4	3 28	56 32	57482	2	42518	60786	2	39214	03304	0	96696	56
5	9 3 20	2 56 40	9.57514	3	10.42486	9.60823	3	10.39177	10.03309	0	9.96691	55
6	3 12	56 48	57545	3	42455	60859	4	39141	03314	1	96686	54
7	3 4	56 56	57576	4	42424	60895	4	39105	03319	1	96681	53
8	2 56	57 4	57607	4	42393	60931	5	39069	03324	1	96676	52
9	2 48	57 12	57638	5	42362	60967	5	39033	03330	1	96670	51
10	9 2 40	2 57 20	9.57669	5	10.42331	9.61004	6	10.38996	10.03335	1	9.96665	50
11	2 32	57 28	57700	6	42300	61040	7	38960	03340	1	96660	49
12	2 24	57 36	57731	6	42269	61076	7	38924	03345	1	96655	48
13	2 16	57 44	57762	7	42238	61112	8	38888	03350	1	96650	47
14	2 8	57 52	57793	7	42207	61148	8	38852	03355	1	96645	46
15	9 2 0	2 58 0	9.57824	8	10.42176	9.61184	9	10.38816	10.03360	1	9.96640	45
16	1 52	58 8	57855	8	42145	61220	10	38780	03366	1	96634	44
17	1 44	58 16	57885	9	42115	61256	10	38744	03371	1	96629	43
18	1 36	58 24	57916	9	42084	61292	11	38708	03376	2	96624	42
19	1 28	58 32	57947	10	42053	61328	11	38672	03381	2	96619	41
20	9 1 20	2 58 40	9.57978	10	10.42022	9.61364	12	10.38636	10.03386	2	9.96614	40
21	1 12	58 48	58008	11	41992	61400	13	38600	03392	2	96608	39
22	1 4	58 56	58039	11	41961	61436	13	38564	03397	2	96603	38
23	0 56	59 4	58070	12	41930	61472	14	38528	03402	2	96598	37
24	0 48	59 12	58101	12	41899	61508	14	38492	03407	2	96593	36
25	9 0 40	2 59 20	9.58131	13	10.41869	9.61544	15	10.38456	10.03412	2	9.96588	35
26	0 32	59 28	58162	13	41838	61579	15	38421	03418	2	96582	34
27	0 24	59 36	58192	14	41808	61615	16	38385	03423	2	96577	33
28	0 16	59 44	58223	14	41777	61651	17	38349	03428	2	96572	32
29	0 8	59 52	58253	15	41747	61687	17	38313	03433	3	96567	31
30	9 0 0	3 0 0	9.58284	15	10.41716	9.61722	18	10.38278	10.03438	3	9.96562	30
31	8 59 52	0 8	58314	16	41686	61758	18	38242	03444	3	96556	29
32	59 44	0 16	58345	16	41655	61794	19	38206	03449	3	96551	28
33	59 36	0 24	58375	17	41625	61830	20	38170	03454	3	96546	27
34	59 28	0 32	58406	17	41594	61865	20	38135	03459	3	96541	26
35	8 59 20	3 0 40	9.58436	18	10.41564	9.61901	21	10.38099	10.03465	3	9.96535	25
36	59 12	0 48	58467	18	41533	61936	21	38064	03470	3	96530	24
37	59 4	0 56	58497	19	41503	61972	22	38028	03475	3	96525	23
38	58 56	1 4	58527	19	41473	62008	23	37992	03480	3	96520	22
39	58 48	1 12	58557	20	41443	62043	23	37957	03486	3	96514	21
40	8 58 40	3 1 20	9.58588	20	10.41412	9.62079	24	10.37921	10.03491	3	9.96509	20
41	58 32	1 28	58618	21	41382	62114	24	37886	03496	4	96504	19
42	58 24	1 36	58648	21	41352	62150	25	37850	03502	4	96498	18
43	58 16	1 44	58678	22	41322	62185	26	37815	03507	4	96493	17
44	58 8	1 52	58709	22	41291	62221	26	37779	03512	4	96488	16
45	8 58 0	3 2 0	9.58739	23	10.41261	9.62256	27	10.37744	10.03517	4	9.96483	15
46	57 52	2 8	58769	23	41231	62292	27	37708	03523	4	96477	14
47	57 44	2 16	58799	24	41201	62327	28	37673	03528	4	96472	13
48	57 36	2 24	58829	24	41171	62362	29	37638	03533	4	96467	12
49	57 28	2 32	58859	25	41141	62398	29	37602	03539	4	96461	11
50	8 57 20	3 2 40	9.58889	25	10.41111	9.62433	30	10.37567	10.03544	4	9.96456	10
51	57 12	2 48	58919	26	41081	62468	30	37532	03549	4	96451	9
52	57 4	2 56	58949	26	41051	62504	31	37496	03555	5	96445	8
53	56 56	3 4	58979	27	41021	62539	32	37461	03560	5	96440	7
54	56 48	3 12	59009	27	40991	62574	32	37426	03565	5	96435	6
55	8 56 40	3 3 20	9.59039	28	10.40961	9.62609	33	10.37391	10.03571	5	9.96429	5
56	56 32	3 28	59069	28	40931	62645	33	37355	03576	5	96424	4
57	56 24	3 36	59098	29	40902	62680	34	37320	03581	5	96419	3
58	56 16	3 44	59128	29	40872	62715	35	37285	03587	5	96413	2
59	56 8	3 52	59158	30	40842	62750	35	37250	03592	5	96408	1
60	56 0	4 0	59188	31	40812	62785	36	37215	03597	5	96403	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

112° | A | A | B | B | C | C | 67°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	4	8	11	15	19	23	27
	B	4	9	13	18	22	27	31
	C	1	1	2	3	3	4	5

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

8^h. 3^h.

23° | A | A | B | B | C | C 156°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	8 56 0	3 4 0	9.59188	0	10.40812	9.62785	0	10.37215	10.03597	0	9.96403	60
1	55 52	4 8	59218	0	40782	62820	1	37180	03603	0	96397	59
2	55 44	4 16	59247	1	40753	62855	1	37145	03608	0	96392	58
3	55 36	4 24	59277	1	40723	62890	2	37110	03613	0	96387	57
4	55 28	4 32	59307	2	40693	62926	2	37074	03619	0	96381	56
5	8 55 20	3 4 40	9.59336	2	10.40664	9.62961	3	10.37039	10.03624	0	9.96376	55
6	55 12	4 48	59366	3	40634	62996	3	37004	03630	1	96370	54
7	55 4	4 56	59396	3	40604	63031	4	36969	03635	1	96365	53
8	54 56	5 4	59425	4	40575	63066	5	36934	03640	1	96360	52
9	54 48	5 12	59455	4	40545	63101	5	36899	03646	1	96354	51
10	8 54 40	3 5 20	9.59484	5	10.40516	9.63135	6	10.36865	10.03651	1	9.96349	50
11	54 32	5 28	59514	5	40486	63170	6	36830	03657	1	96343	49
12	54 24	5 36	59543	6	40457	63205	7	36795	03662	1	96338	48
13	54 16	5 44	59573	6	40427	63240	7	36760	03667	1	96333	47
14	54 8	5 52	59602	7	40398	63275	8	36725	03673	1	96327	46
15	8 54 0	3 6 0	9.59632	7	10.40368	9.63310	9	10.36690	10.03678	1	9.96322	45
16	53 52	6 8	59661	8	40339	63345	9	36655	03684	1	96316	44
17	53 44	6 16	59690	8	40310	63379	10	36621	03689	2	96311	43
18	53 36	6 24	59720	9	40280	63414	10	36586	03695	2	96305	42
19	53 28	6 32	59749	9	40251	63449	11	36551	03700	2	96300	41
20	8 53 20	3 6 40	9.59778	10	10.40222	9.63484	12	10.36516	10.03706	2	9.96294	40
21	53 12	6 48	59808	10	40192	63519	12	36481	03711	2	96289	39
22	53 4	6 56	59837	11	40163	63553	13	36447	03716	2	96284	38
23	52 56	7 4	59866	11	40134	63588	13	36412	03722	2	96278	37
24	52 48	7 12	59895	12	40105	63623	14	36377	03727	2	96273	35
25	8 52 40	3 7 20	9.59924	12	10.40076	9.63657	14	10.36343	10.03733	2	9.96267	35
26	52 32	7 28	59954	13	40046	63692	15	36308	03738	2	96262	34
27	52 24	7 36	59983	13	40017	63726	16	36274	03744	2	96256	33
28	52 16	7 44	60012	14	39988	63761	16	36239	03749	3	96251	32
29	52 8	7 52	60041	14	39959	63796	17	36204	03755	3	96245	31
30	8 52 0	3 8 0	9.60070	15	10.39930	9.63830	17	10.36170	10.03760	3	9.96240	30
31	51 52	8 8	60099	15	39901	63865	18	36135	03766	3	96234	29
32	51 44	8 16	60128	15	39872	63899	18	36101	03771	3	96229	28
33	51 36	8 24	60157	16	39843	63934	19	36066	03777	3	96223	27
34	51 28	8 32	60186	16	39814	63968	20	36032	03782	3	96218	26
35	8 51 20	3 8 40	9.60215	17	10.39785	9.64003	20	10.35997	10.03788	3	9.96212	25
36	51 12	8 48	60244	17	39756	64037	21	35963	03793	3	96207	24
37	51 4	8 56	60273	18	39727	64072	21	35928	03799	3	96201	23
38	50 56	9 4	60302	18	39698	64106	22	35894	03804	3	96196	22
39	50 48	9 12	60331	19	39669	64140	22	35860	03810	4	96190	21
40	8 50 40	3 9 20	9.60359	19	10.39641	9.64175	23	10.35825	10.03815	4	9.96185	20
41	50 32	9 28	60388	20	39612	64209	24	35791	03821	4	96179	19
42	50 24	9 36	60417	20	39583	64243	24	35757	03826	4	96174	18
43	50 16	9 44	60446	21	39554	64278	25	35722	03832	4	96168	17
44	50 8	9 52	60474	21	39526	64312	25	35688	03838	4	96162	16
45	8 50 0	3 10 0	9.60503	22	10.39497	9.64346	26	10.35654	10.03843	4	9.96157	15
46	49 52	10 8	60532	22	39468	64381	26	35619	03849	4	96151	14
47	49 44	10 16	60561	23	39439	64415	27	35585	03854	4	96146	13
48	49 36	10 24	60589	23	39411	64449	28	35551	03860	4	96140	12
49	49 28	10 32	60618	24	39382	64483	28	35517	03865	4	96135	11
50	8 49 20	3 10 40	9.60646	24	10.39354	9.64517	29	10.35483	10.03871	5	9.96129	10
51	49 12	10 48	60675	25	39325	64552	29	35448	03877	5	96123	9
52	49 4	10 56	60704	25	39296	64586	30	35414	03882	5	96118	8
53	48 56	11 4	60732	26	39268	64620	31	35380	03888	5	96112	7
54	48 48	11 12	60761	26	39239	64654	31	35346	03893	5	96107	6
55	8 48 40	3 11 20	9.60789	27	10.39211	9.64688	32	10.35312	10.03899	5	9.96101	5
56	48 32	11 28	60818	27	39182	64722	32	35278	03905	5	96095	4
57	48 24	11 36	60846	28	39154	64756	33	35244	03910	5	96090	3
58	48 16	11 44	60875	28	39125	64790	33	35210	03916	5	96084	2
59	48 8	11 52	60903	29	39097	64824	34	35176	03921	5	96079	1
60	48 0	12 0	60931	29	39069	64858	35	35142	03927	6	96073	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

13° | A | A | B | B | C | C 66°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	4	7	11	15	18	22	25
	B	4	9	13	17	22	26	31
	C	1	1	2	3	3	4	5

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

8ʰ | 24° | 155° | 6ʰ.

M	Hour A.M.	Hour P.M.	Sine. (A)	Diff.	Cosecant. (A)	Tangent. (B)	Diff.	Cotangent (B)	Secant. (C)	Diff.	Cosine. (C)	M
0	8 48 0	3 12 0	9.60931	0	10.39069	9.64858	0	10.35142	10.03927	0	9.96073	60
1	47 52	12 8	60960	0	39040	64892	1	35108	03933	0	96067	59
2	47 44	12 16	60988	1	39012	64926	1	35074	03938	0	96062	58
3	47 36	12 24	61016	1	38984	64960	2	35040	03914	0	96056	57
4	47 28	12 32	61045	2	38955	64994	2	35006	03950	0	96050	56
5	8 47 20	3 12 40	9.61073	2	10.38927	9.65028	3	10.34972	10.03955	0	9.96045	55
6	47 12	12 48	61101	3	38899	65062	3	34938	03961	1	96039	54
7	47 4	12 56	61129	3	38871	65096	4	34904	03966	1	96034	53
8	46 56	13 4	61158	4	38842	65130	4	34870	03972	1	96028	52
9	46 48	13 12	61186	4	38814	65164	5	34836	03978	1	96022	51
10	8 46 40	3 13 20	9.61214	5	10.38786	9.65197	6	10.34803	10.03983	1	9.96017	50
11	46 32	13 28	61242	5	38758	65231	6	34769	03989	1	96011	49
12	46 24	13 36	61270	6	38730	65265	7	34735	03995	1	96005	48
13	46 16	13 44	61298	6	38702	65299	7	34701	04000	1	96000	47
14	46 8	13 52	61326	6	38674	65333	8	34667	04006	1	95994	46
15	8 46 0	3 14 0	9.61354	7	10.38646	9.65366	8	10.34634	10.04012	1	9.95988	45
16	45 52	14 8	61382	7	38618	65400	9	34600	04018	2	95982	44
17	45 44	14 16	61411	8	38589	65434	9	34566	04023	2	95977	43
18	45 36	14 24	61438	8	38562	65467	10	34533	04029	2	95971	42
19	45 28	14 32	61466	9	38534	65501	11	34499	04035	2	95965	41
20	8 45 20	3 14 40	9.61494	9	10.38506	9.65535	11	10.34465	10.04040	2	9.95960	40
21	45 12	14 48	61522	10	38478	65568	12	34432	04046	2	95954	39
22	45 4	14 56	61550	10	38450	65602	12	34398	04052	2	95948	38
23	44 56	15 4	61578	11	38422	65636	13	34364	04058	2	95942	37
24	44 48	15 12	61606	11	38394	65669	13	34331	04063	2	95937	36
25	8 44 40	3 15 20	9.61634	12	10.38366	9.65703	14	10.34297	10.04069	2	9.95931	35
26	44 32	15 28	61662	12	38338	65736	15	34264	04075	2	95925	34
27	44 24	15 36	61689	12	38311	65770	15	34230	04080	3	95920	33
28	44 16	15 44	61717	13	38283	65803	16	34197	04086	3	95914	32
29	44 8	15 52	61745	13	38255	65837	16	34163	04092	3	95908	31
30	8 44 0	3 16 0	9.61773	14	10.38227	9.65870	17	10.34130	10.04098	3	9.95902	30
31	43 52	16 8	61800	14	38200	65904	17	34096	04103	3	95897	29
32	43 44	16 16	61828	15	38172	65937	18	34063	04109	3	95891	28
33	43 36	16 24	61856	15	38144	65971	18	34029	04115	3	95885	27
34	43 28	16 32	61883	16	38117	66004	19	33996	0412[illegible]	3	95879	26
35	8 43 20	3 16 40	9.61911	16	10.38089	9.66038	20	10.33962	10.04127	3	9.95873	25
36	43 12	16 48	61939	17	38061	66071	20	33929	04132	3	95868	24
37	43 4	16 56	61966	17	38034	66104	21	33896	04138	4	95862	23
38	42 56	17 4	61994	18	38006	66138	21	33862	04144	4	95856	22
39	42 48	17 12	62021	18	37979	66171	22	33829	04160	4	95850	21
40	8 42 40	3 17 20	9.62049	18	10.37951	9.66204	22	10.33796	10.04156	4	9.95844	[illegible]
41	42 32	17 28	62076	19	37924	66238	23	33762	04161	4	95839	19
42	42 24	17 36	62104	19	37896	66271	23	33729	04167	4	95833	18
43	42 16	17 44	62131	20	37869	66304	24	33696	04173	4	95827	17
44	42 8	17 52	62159	20	37841	66337	25	33663	04179	4	95821	16
45	8 42 0	3 18 0	9.62186	21	10.37814	9.66371	25	10.33629	10.04185	4	9.95815	15
46	41 52	18 8	62214	21	37786	66404	26	33596	04190	4	95810	14
47	41 44	18 16	62241	22	37759	66437	26	33563	04196	5	95804	13
48	41 36	18 24	62268	22	37732	66470	27	33530	04202	5	95798	12
49	41 28	18 32	62296	23	37704	66503	27	33497	04208	5	95792	11
50	8 41 20	3 18 40	9.62323	23	10.37677	9.66537	28	10.33463	10.04214	5	9.95786	10
51	41 12	18 48	62350	24	37650	66570	28	33430	042[illegible]0	5	95780	9
52	41 4	18 56	62377	24	37623	66603	29	33397	042[illegible]5	5	95775	8
53	40 56	19 4	62405	24	37595	66636	30	33364	04231	5	95769	7
54	40 48	19 12	62432	25	37568	66669	30	33331	04237	5	95763	6
55	8 40 40	3 19 20	9.62459	25	10.37541	9.66702	31	10.33298	10.04243	5	9.95757	5
56	40 32	19 28	62486	26	37514	66735	31	33265	04249	5	95751	4
57	40 24	19 36	62513	26	37487	66768	32	33232	04255	5	95745	3
58	40 16	19 44	62541	27	37459	66801	32	33199	04261	6	95739	2
59	40 8	19 52	62568	27	37432	66834	33	33166	04267	6	95733	1
60	40 0	20 0	62595	28	37405	66867	33	33133	04272	6	95728	0
M	Hour P.M.	Hour A.M.	Cosine. (A)	Diff.	Secant. (A)	Cotangent (B)	Diff.	Tangent. (B)	Cosecant. (C)	Diff.	Sine. (C)	M

114° | 65°

Seconds of time ……		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	3	7	10	14	17	21	24
	B	4	8	13	17	21	25	29
	C	1	1	2	3	4	4	5

Digitized by Google

TABLE XXVII.

S'. | Log. Sines, Tangents, and Secants. | 4h.

25° | A | A | B | B | C | C 154°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	8 40 0	3 20 0	9.62595	0	10.37405	9.66867	0	10.33133	10.04272	0	9.95728	60
1	39 52	20 8	62622	0	37378	66900	1	33100	04278	0	95722	59
2	39 44	20 16	62649	1	37351	66933	1	33067	04284	0	95716	58
3	39 36	20 24	62676	1	37324	66966	2	33034	04290	0	95710	57
4	39 28	20 32	62703	2	37297	66999	2	33001	04296	0	95704	56
5	8 39 20	3 20 40	9.62730	2	10.37270	9.67032	3	10.32968	10.04302	1	9.95698	55
6	39 12	20 48	62757	3	37243	67065	3	32935	04308	1	95692	54
7	39 4	20 56	62784	3	37216	67098	4	32902	04314	1	95686	53
8	38 56	21 4	62811	4	37189	67131	4	32869	04320	1	95680	52
9	38 48	21 12	62838	4	37162	67163	5	32837	04326	1	95674	51
10	8 38 40	3 21 20	9.62865	4	10.37135	9.67196	5	10.32804	10.04332	1	9.95668	50
11	38 32	21 28	62892	5	37108	67229	6	32771	04337	1	95663	49
12	38 24	21 36	62918	5	37082	67262	7	32738	04343	1	95657	48
13	38 16	21 44	62945	6	37055	67295	7	32705	04349	1	95651	47
14	38 8	21 52	62972	6	37028	67327	8	32673	04355	1	95645	46
15	8 38 0	3 22 0	9.62999	7	10.37001	9.67360	8	10.32640	10.04361	2	9.95639	45
16	37 52	22 8	63026	7	36974	67393	9	32607	04367	2	95633	44
17	37 44	22 16	63052	8	36948	67426	9	32574	04373	2	95627	43
18	37 36	22 24	63079	8	36921	67458	10	32542	04379	2	95621	42
19	37 28	22 32	63106	8	36894	67491	10	32509	04385	2	95615	41
20	8 37 20	3 22 40	9.63133	9	10.36867	9.67524	11	10.32476	10.04391	2	9.95609	40
21	37 12	22 48	63159	9	36841	67556	11	32444	04397	2	95603	39
22	37 4	22 56	63186	10	36814	67589	12	32411	04403	2	95597	38
23	36 56	23 4	63213	10	36787	67622	12	32378	04409	2	95591	37
24	36 48	23 12	63239	11	36761	67654	13	32346	04415	2	95585	36
25	8 36 40	3 23 20	9.63266	11	10.36734	9.67687	14	10.32313	10.04421	3	9.95579	35
26	36 32	23 28	63292	11	36708	67719	14	32281	04427	3	95573	34
27	36 24	23 36	63319	12	36681	67752	15	32248	04433	3	95567	33
28	36 16	23 44	63345	12	36655	67785	15	32215	04439	3	95561	32
29	36 8	23 52	63372	13	36628	67817	16	32183	04445	3	95555	31
30	8 36 0	3 24 0	9.63398	13	10.36602	9.67850	16	10.32150	10.04451	3	9.95549	30
31	35 52	24 8	63425	14	36575	67882	17	32118	04457	3	95543	29
32	35 44	24 16	63451	14	36549	67915	17	32085	04463	3	95537	28
33	35 36	24 24	63478	15	36522	67947	18	32053	04469	3	95531	27
34	35 28	24 32	63504	15	36496	67980	18	32020	04475	3	95525	26
35	8 35 20	3 24 40	9.63531	15	10.36469	9.68012	19	10.31988	10.04481	4	9.95519	25
36	35 12	24 48	63557	16	36443	68044	20	31956	04487	4	95513	24
37	35 4	24 56	63583	16	36417	68077	20	31923	04493	4	95507	23
38	34 56	25 4	63610	17	36390	68109	21	31891	04500	4	95500	22
39	34 48	25 12	63636	17	36364	68142	21	31858	04506	4	95494	21
40	8 34 40	3 25 20	9.63662	18	10.36338	9.68174	22	10.31826	10.04512	4	9.95488	20
41	34 32	25 28	63689	18	36311	68206	22	31794	04518	4	95482	19
42	34 24	25 36	63715	19	36285	68239	23	31761	04524	4	95476	18
43	34 16	25 44	63741	19	36259	68271	23	31729	04530	4	95470	17
44	34 8	25 52	63767	19	36233	68303	24	31697	04536	4	95464	16
45	8 34 0	3 26 0	9.63794	20	10.36206	9.68336	24	10.31664	10.04542	5	9.95458	15
46	33 52	26 8	63820	20	36180	68368	25	31632	04548	5	95452	14
47	33 44	26 16	63846	21	36154	68400	25	31600	04554	5	95446	13
48	33 36	26 24	63872	21	36128	68432	26	31568	04560	5	95440	12
49	33 28	26 32	63898	22	36102	68465	27	31535	04566	5	95434	11
50	8 33 20	3 26 40	9.63924	22	10.36076	9.68497	27	10.31503	10.04573	5	9.95427	10
51	33 12	26 48	63950	23	36050	68529	28	31471	04579	5	95421	9
52	33 4	26 56	63976	23	36024	68561	28	31439	04585	5	95415	8
53	32 56	27 4	64002	23	35998	68593	29	31407	04591	5	95409	7
54	32 48	27 12	64028	24	35972	68626	29	31374	04597	5	95403	6
55	8 32 40	3 27 20	9.64054	24	10.35946	9.68658	30	10.31342	10.04603	6	9.95397	5
56	32 32	27 28	64080	25	35920	68690	30	31310	04609	6	95391	4
57	32 24	27 36	64106	25	35894	68722	31	31278	04616	6	95384	3
58	32 16	27 44	64132	26	35868	68754	31	31246	04622	6	95378	2
59	32 8	27 52	64158	26	35842	68786	32	31214	04628	6	95372	1
60	32 0	28 0	64184	26	35816	68818	33	31182	04634	6	95366	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

115° | A | A | B | B | C | C 64°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	3	7	10	13	17	20	23
	B	4	8	12	16	20	24	28
	C	1	2	2	3	4	5	5

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants

S'. 26° | G'. 153°

M	Hour A.M.	Hour P.M.	A Sine.	Diff.	A Cosecant.	B Tangent.	Diff.	B Cotangent	C Secant.	Diff.	C Cosine.	M
0	8 32 0	3 28 0	9.64184	0	10.35816	9.68818	0	10.31182	10.04634	0	9.95366	60
1	31 52	28 8	64210	0	35790	68850	1	31150	04640	0	95360	59
2	31 44	28 16	64236	1	35764	68882	1	31118	04646	0	95354	58
3	31 36	28 24	64262	1	35738	68914	2	31086	04652	0	95348	57
4	31 28	28 32	64288	2	35712	68946	2	31054	04659	0	95341	56
5	8 31 20	3 28 40	9.64313	2	10.35687	9.68978	3	10.31022	10.04665	1	9.95335	55
6	31 12	28 48	64339	3	35661	69010	3	30990	04671	1	95329	54
7	31 4	28 56	64365	3	35635	69042	4	30958	04677	1	95323	53
8	30 56	29 4	64391	3	35609	69074	4	30926	04683	1	95317	52
9	30 48	29 12	64417	4	35583	69106	5	30894	04690	1	95310	51
10	8 30 40	3 29 20	9.64442	4	10.35558	9.69138	5	10.30862	10.04696	1	9.95304	50
11	30 32	29 28	64468	5	35532	69170	6	30830	04702	1	95298	49
12	30 24	29 36	64494	5	35506	69202	6	30798	04708	1	95292	48
13	30 16	29 44	64519	5	35481	69234	7	30766	04714	1	95286	47
14	30 8	29 52	64545	6	35455	69266	7	30734	04721	1	95279	46
15	8 30 0	3 30 0	9.64571	6	10.35429	9.69298	8	10.30702	10.04727	2	9.95273	45
16	29 52	30 8	64596	7	35404	69329	8	30671	04733	2	95267	44
17	29 44	30 16	64622	7	35378	69361	9	30639	04739	2	95261	43
18	29 36	30 24	64647	8	35353	69393	9	30607	04746	2	95254	42
19	29 28	30 32	64673	8	35327	69425	10	30575	04752	2	95248	41
20	8 29 20	3 30 40	9.64698	8	10.35302	9.69457	11	10.30543	10.04758	2	9.95242	40
21	29 12	30 48	64724	9	35276	69488	11	30512	04764	2	95236	39
22	29 4	30 56	64749	9	35251	69520	12	30480	04771	2	95229	38
23	28 56	31 4	64775	10	35225	69552	12	30448	04777	2	95223	37
24	28 48	31 12	64800	10	35200	69584	13	30416	04783	3	95217	36
25	8 28 40	3 31 20	9.64826	11	10.35174	9.69615	13	10.30385	10.04789	3	9.95211	35
26	28 32	31 28	64851	11	35149	69647	14	30353	04796	3	95204	34
27	28 24	31 36	64877	11	35123	69679	14	30321	04802	3	95198	33
28	28 16	31 44	64902	12	35098	69710	15	30290	04808	3	95192	32
29	28 8	31 52	64927	12	35073	69742	15	30258	04815	3	95185	31
30	8 28 0	3 32 0	9.64953	13	10.35047	9.69774	16	10.30226	10.04821	3	9.95179	30
31	27 52	32 8	64978	13	35022	69805	16	30195	04827	3	95173	29
32	27 44	32 16	65003	14	34997	69837	17	30163	04833	3	95167	28
33	27 36	32 24	65029	14	34971	69868	17	30132	04840	3	95160	27
34	27 28	32 32	65054	14	34946	69900	18	30100	04846	4	95154	26
35	8 27 20	3 32 40	9.65079	15	10.34921	9.69932	18	10.30068	10.04852	4	9.95148	25
36	27 12	32 48	65104	15	34896	69963	19	30037	04859	4	95141	24
37	27 4	32 56	65130	16	34870	69995	20	30005	04865	4	95135	23
38	26 56	33 4	65155	16	34845	70026	20	29974	04871	4	95129	22
39	26 48	33 12	65180	16	34820	70058	21	29942	04878	4	95122	21
40	8 26 40	3 33 20	9.65205	17	10.34795	9.70089	21	10.29911	10.04884	4	9.95116	20
41	26 32	33 28	65230	17	34770	70121	22	29879	04890	4	95110	19
42	26 24	33 36	65255	18	34745	70152	22	29848	04897	4	95103	18
43	26 16	33 44	65281	18	34719	70184	23	29816	04903	5	95097	17
44	26 8	33 52	65306	19	34694	70215	23	29785	04910	5	95090	16
45	8 26 0	3 34 0	9.65331	19	10.34669	9.70247	24	10.29753	10.04916	5	9.95084	15
46	25 52	34 8	65356	19	34644	70278	24	29722	04922	5	95078	14
47	25 44	34 16	65381	20	34619	70309	25	29691	04929	5	95071	13
48	25 36	34 24	65406	20	34594	70341	25	29659	04935	5	95065	12
49	25 28	34 32	65431	21	34569	70372	26	29628	04941	5	95059	11
50	8 25 20	3 34 40	9.65456	21	10.34544	9.70404	26	10.29596	10.04948	5	9.95052	10
51	25 12	34 48	65481	22	34519	70435	27	29565	04954	5	95046	9
52	25 4	34 56	65506	22	34494	70466	27	29534	04961	5	95039	8
53	24 56	35 4	65531	22	34469	70498	28	29502	04967	6	95033	7
54	24 48	35 12	65556	23	34444	70529	28	29471	04973	6	95027	6
55	8 24 40	3 35 20	9.65580	23	10.34420	9.70560	29	10.29440	10.04980	6	9.95020	5
56	24 32	35 28	65605	24	34395	70592	30	29408	04986	6	95014	4
57	24 24	35 36	65630	24	34370	70623	30	29377	04993	6	95007	3
58	24 16	35 44	65655	25	34345	70654	31	29346	04999	6	95001	2
59	24 8	35 52	65680	25	34320	70685	31	29315	05005	6	94995	1
60	24 0	36 0	65705	25	34295	70717	32	29283	05012	6	94988	0
M	Hour P.M.	Hour A.M.	A Cosine.	Diff.	A Secant.	B Cotangent	Diff.	B Tangent.	C Cosecant.	Diff.	C Sine.	M

116° | 63°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols	A	3	6	10	13	16	19	22
	B	4	8	12	16	20	24	28

TABLE XXVII.

Log. Sines, Tangents, and Secants.

27° | A | A | B | B | C | C 152°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	8 24 0	3 36 0	9.65705	0	10.34295	9.70717	0	10.29283	10.05012	0	9.94988	60
1	23 52	36 8	65729	0	34271	70748	1	29252	05018	0	94982	59
2	23 44	36 16	65754	1	34246	70779	1	29221	05025	0	94975	58
3	23 36	36 24	65779	1	34221	70810	2	29190	05031	0	94969	57
4	23 28	36 32	65804	2	34196	70841	2	29159	05038	0	94962	56
5	8 23 20	3 36 40	9.65828	2	10.34172	9.70873	3	10.29127	10.05044	1	9.94956	55
6	23 12	36 48	65853	2	34147	70904	3	29096	05051	1	94949	54
7	23 4	36 56	65878	3	34122	70935	4	29065	05057	1	94943	53
8	22 56	37 4	65902	3	34098	70966	4	29034	05064	1	94936	52
9	22 48	37 12	65927	4	34073	70997	5	29003	05070	1	94930	51
10	8 22 40	3 37 20	9.65952	4	10.34048	9.71028	5	10.28972	10.05077	1	9.94923	50
11	22 32	37 28	65976	4	34024	71059	6	28941	05083	1	94917	49
12	22 24	37 36	66001	5	33999	71090	6	28910	05089	1	94911	48
13	22 16	37 44	66025	5	33975	71121	7	28879	05096	1	94904	47
14	22 8	37 52	66050	6	33950	71153	7	28847	05102	2	94898	46
15	8 22 0	3 38 0	9.66075	6	10.33925	9.71184	8	10.28816	10.05109	2	9.94891	45
16	21 52	38 8	66099	6	33901	71215	8	28785	05115	2	94885	44
17	21 44	38 16	66124	7	33876	71246	9	28754	05122	2	94878	43
18	21 36	38 24	66148	7	33852	71277	9	28723	05129	2	94871	42
19	21 28	38 32	66173	8	33827	71308	10	28692	05135	2	94865	41
20	8 21 20	3 38 40	9.66197	8	10.33803	9.71339	10	10.28661	10.05142	2	9.94858	40
21	21 12	38 48	66221	8	33779	71370	11	28630	05148	2	94852	39
22	21 4	38 56	66246	9	33754	71401	11	28599	05155	2	94845	38
23	20 56	39 4	66270	9	33730	71431	12	28569	05161	3	94839	37
24	20 48	39 12	66295	10	33705	71462	12	28538	05168	3	94832	36
25	8 20 40	3 39 20	9.66319	10	10.33681	9.71493	13	10.28507	10.05174	3	9.94826	35
26	20 32	39 28	66343	11	33657	71524	13	28476	05181	3	94819	34
27	20 24	39 36	66368	11	33632	71555	14	28445	05187	3	94813	33
28	20 16	39 44	66392	11	33608	71586	14	28414	05194	3	94806	32
29	20 8	39 52	66416	12	33584	71617	15	28383	05201	3	94799	31
30	8 20 0	3 40 0	9.66441	12	10.33559	9.71648	15	10.28352	10.05207	3	9.94793	30
31	19 52	40 8	66465	13	33535	71679	16	28321	05214	3	94786	29
32	19 44	40 16	66489	13	33511	71709	16	28291	05220	4	94780	28
33	19 36	40 24	66513	13	33487	71740	17	28260	05227	4	94773	27
34	19 28	40 32	66537	14	33463	71771	17	28229	05233	4	94767	26
35	8 19 20	3 40 40	9.66562	14	10.33438	9.71802	18	10.28198	10.05240	4	9.94760	25
36	19 12	40 48	66586	15	33414	71833	19	28167	05247	4	94753	24
37	19 4	40 56	66610	15	33390	71863	19	28137	05253	4	94747	23
38	18 56	41 4	66634	15	33366	71894	20	28106	05260	4	94740	22
39	18 48	41 12	66658	16	33342	71925	20	28075	05266	4	94734	21
40	8 18 40	3 41 20	9.66682	16	10.33318	9.71955	21	10.28045	10.05273	4	9.94727	20
41	18 32	41 28	66706	17	33294	71986	21	28014	05280	4	94720	19
42	18 24	41 36	66731	17	33269	72017	22	27983	05286	5	94714	18
43	18 16	41 44	66755	17	33245	72048	22	27952	05293	5	94707	17
44	18 8	41 52	66779	18	33221	72078	23	27922	05300	5	94700	16
45	8 18 0	3 42 0	9.66803	18	10.33197	9.72109	23	10.27891	10.05306	5	9.94694	15
46	17 52	42 8	66827	19	33173	72140	24	27860	05313	5	94687	14
47	17 44	42 16	66851	19	33149	72170	24	27830	05320	5	94680	13
48	17 36	42 24	66875	19	33125	72201	25	27799	05326	5	94674	12
49	17 28	42 32	66899	20	33101	72231	25	27769	05333	5	94667	11
50	8 17 20	3 42 40	9.66922	20	10.33078	9.72262	26	10.27738	10.05340	5	9.94660	10
51	17 12	42 48	66946	21	33054	72293	26	27707	05346	6	94654	9
52	17 4	42 56	66970	21	33030	72323	27	27677	05353	6	94647	8
53	16 56	43 4	66994	21	33006	72354	27	27646	05360	6	94640	7
54	16 48	43 12	67018	22	32982	72384	28	27616	05366	6	94634	6
55	8 16 40	3 43 20	9.67042	22	10.32958	9.72415	28	10.27585	10.05373	6	9.94627	5
56	16 32	43 28	67066	23	32934	72445	29	27555	05380	6	94620	4
57	16 24	43 36	67090	23	32910	72476	29	27524	05386	6	94614	3
58	16 16	43 44	67113	23	32887	72506	30	27494	05393	6	94607	2
59	16 8	43 52	67137	24	32863	72537	30	27463	05400	6	94600	1
60	16 0	44 0	67161	24	32839	72567	31	27433	05407	7	94593	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

117° | A | A | B | B | C | C 62°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	3	6	9	12	15	18	21
	B	4	8	12	15	19	23	27
	C	[illegible]	[illegible]	[illegible]	3	4	5	6

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

S'. 28°			A		A	B		B	C		C	G'. 151°
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	8 16 0	3 44 0	9.67161	0	10.32839	9.72567	0	10.27433	10.05407	0	9.94593	60
1	15 52	44 8	67185	0	32815	72598	1	27402	05413	0	94587	59
2	15 44	44 16	67208	1	32792	72628	1	27372	05420	0	94580	58
3	15 36	44 24	67232	1	32768	72659	2	27341	05427	0	94573	57
4	15 28	44 32	67256	2	32744	72689	2	27311	05433	0	94567	56
5	8 15 20	3 44 40	9.67280	2	10.32720	9.72720	3	10.27280	10.05440	1	9.94560	55
6	15 12	44 48	67303	2	32697	72750	3	27250	05447	1	94553	54
7	15 4	44 56	67327	3	32673	72780	4	27220	05454	1	94546	53
8	14 56	45 4	67350	3	32650	72811	4	27189	05460	1	94540	52
9	14 48	45 12	67374	3	32626	72841	5	27159	05467	1	94533	51
10	8 14 40	3 45 20	9.67398	4	10.32602	9.72872	5	10.27128	10.05474	1	9.94526	50
11	14 32	45 28	67421	4	32579	72902	6	27098	05481	1	94519	49
12	14 24	45 36	67445	5	32555	72932	6	27068	05487	1	94513	48
13	14 16	45 44	67468	5	32532	72963	7	27037	05494	1	94506	47
14	14 8	45 52	67492	5	32508	72993	7	27007	05501	2	94499	46
15	8 14 0	3 46 0	9.67515	6	10.32485	9.73023	8	10.26977	10.05508	2	9.94492	45
16	13 52	46 8	67539	6	32461	73054	8	26946	05515	2	94485	44
17	13 44	46 16	67562	7	32438	73084	9	26916	05521	2	94479	43
18	13 36	46 24	67586	7	32414	73114	9	26886	05528	2	94472	42
19	13 28	46 32	67609	7	32391	73144	10	26856	05535	2	94465	41
20	8 13 20	3 46 40	9.67633	8	10.32367	9.73175	10	10.26825	10.05542	2	9.94458	40
21	13 12	46 48	67656	8	32344	73205	11	26795	05549	2	94451	39
22	13 4	46 56	67680	9	32320	73235	11	26765	05555	3	94445	38
23	12 56	47 4	67703	9	32297	73265	12	26735	05562	3	94438	37
24	12 48	47 12	67726	9	32274	73295	12	26705	05569	3	94431	36
25	8 12 40	3 47 20	9.67750	10	10.32250	9.73326	13	10.26674	10.05576	3	9.94424	35
26	12 32	47 28	67773	10	32227	73356	13	26644	05583	3	94417	34
27	12 24	47 36	67796	10	32204	73386	14	26614	05590	3	94410	33
28	12 16	47 44	67820	11	32180	73416	14	26584	05596	3	94404	32
29	12 8	47 52	67843	11	32157	73446	15	26554	05603	3	94397	31
30	8 12 0	3 48 0	9.67866	12	10.32134	9.73476	15	10.26524	10.05610	3	9.94390	30
31	11 52	48 8	67890	12	32110	73507	16	26493	05617	4	94383	29
32	11 44	48 16	67913	12	32087	73537	16	26463	05624	4	94376	28
33	11 36	48 24	67936	13	32064	73567	17	26433	05631	4	94369	27
34	11 28	48 32	67959	13	32041	73597	17	26403	05638	4	94362	26
35	8 11 20	3 48 40	9.67982	14	10.32018	9.73627	18	10.26373	10.05645	4	9.94355	25
36	11 12	48 48	68006	14	31994	73657	18	26343	05651	4	94349	24
37	11 4	48 56	68029	14	31971	73687	19	26313	05658	4	94342	23
38	10 56	49 4	68052	15	31948	73717	19	26283	05665	4	94335	22
39	10 48	49 12	68075	15	31925	73747	20	26253	05672	4	94328	21
40	8 10 40	3 49 20	9.68098	16	10.31902	9.73777	20	10.26223	10.05679	5	9.94321	20
41	10 32	49 28	68121	16	31879	73807	21	26193	05686	5	94314	19
42	10 24	49 36	68144	16	31856	73837	21	26163	05693	5	94307	18
43	10 16	49 44	68167	17	31833	73867	22	26133	05700	5	94300	17
44	10 8	49 52	68190	17	31810	73897	22	26103	05707	5	94293	16
45	8 10 0	3 50 0	9.68213	17	10.31787	9.73927	23	10.26073	10.05714	5	9.94286	15
46	9 52	50 8	68237	18	31763	73957	23	26043	05721	5	94279	14
47	9 44	50 16	68260	18	31740	73987	24	26013	05727	5	94273	13
48	9 36	50 24	68283	19	31717	74017	24	25983	05734	5	94266	12
49	9 28	50 32	68305	19	31695	74047	25	25953	05741	6	94259	11
50	8 9 20	3 50 40	9.68328	19	10.31672	9.74077	25	10.25923	10.05748	6	9.94252	10
51	9 12	50 48	68351	20	31649	74107	26	25893	05755	6	94245	9
52	9 4	50 56	68374	20	31626	74137	26	25863	05762	6	94238	8
53	8 56	51 4	68397	21	31603	74166	27	25834	05769	6	94231	7
54	8 48	51 12	68420	21	31580	74196	27	25804	05776	6	94224	6
55	8 8 40	3 51 20	9.68443	21	10.31557	9.74226	28	10.25774	10.05783	6	9.94217	5
56	8 32	51 28	68466	22	31534	74256	28	25744	05790	6	94210	4
57	8 24	51 36	68489	22	31511	74286	29	25714	05797	7	94203	3
58	8 16	51 44	68512	22	31488	74316	29	25684	05804	7	94196	2
59	8 8	51 52	68534	23	31466	74345	30	25655	05811	7	94189	1
60	8 0	52 0	68557	23	31443	74375	30	25625	05818	7	94182	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
118°			A		A	B		B	C		C	61°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	3	6	9	12	15	17	20
	B	4	8	11	15	19	23	26
	C	1	2	3	3	4	5	6

Digitized by Google

TABLE XXVII.

8h. **Log. Sines, Tangents, and Secants.** 6h

29° A A B B C C 150°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine	M
0	8 8 0	3 52 0	9.68557	0	10.31443	9.74375	0	10.25625	10.05818	0	9.94182	60
1	7 52	52 8	68580	0	31420	74405	0	25595	05825	0	94175	59
2	7 44	52 16	68603	1	31397	74435	1	25565	05832	0	94168	58
3	7 36	52 24	68625	1	31375	74465	1	25535	05839	0	94161	57
4	7 28	52 32	68648	1	31352	74494	2	25506	05846	0	94154	56
5	8 7 20	3 52 40	9.68671	2	10.31329	9.74524	2	10.25476	10.05853	1	9.94147	55
6	7 12	52 48	68694	2	31306	74554	3	25446	05860	1	94140	54
7	7 4	52 56	68716	3	31284	74583	3	25417	05867	1	94133	53
8	6 56	53 4	68739	3	31261	74613	4	25387	05874	1	94126	52
9	6 48	53 12	68762	3	31238	74643	4	25357	05881	1	94119	51
10	8 6 40	3 53 20	9.68784	4	10.31216	9.74673	5	10.25327	10.05888	1	9.94112	50
11	6 32	53 28	68807	4	31193	74702	5	25298	05895	1	94105	49
12	6 24	53 36	68829	4	31171	74732	6	25268	05902	1	94098	48
13	6 16	53 44	68852	5	31148	74762	6	25238	05910	2	94090	47
14	6 8	53 52	68875	5	31125	74791	7	25209	05917	2	94083	46
15	8 6 0	3 54 0	9.68897	6	10.31103	9.74821	7	10.25179	10.05924	2	9.94076	45
16	5 52	54 8	68920	6	31080	74851	8	25149	05931	2	94069	44
17	5 44	54 16	68942	6	31058	74880	8	25120	05938	2	94062	43
18	5 36	54 24	68965	7	31035	74910	9	25090	05945	2	94055	42
19	5 28	54 32	68987	7	31013	74939	9	25061	05952	2	94048	41
20	8 5 20	3 54 40	9.69010	7	10.30990	9.74969	10	10.25031	10.05959	2	9.94041	40
21	5 12	54 48	69032	8	30968	74998	10	25002	05966	3	94034	39
22	5 4	54 56	69055	8	30945	75028	11	24972	05973	3	94027	38
23	4 56	55 4	69077	9	30923	75058	11	24942	05980	3	94020	37
24	4 48	55 12	69100	9	30900	75087	12	24913	05988	3	94012	36
25	8 4 40	3 55 20	9.69122	9	10.30878	9.75117	12	10.24883	10.05995	3	9.94005	35
26	4 32	55 28	69144	10	30856	75146	13	24854	06002	3	93998	34
27	4 24	55 36	69167	10	30833	75176	13	24824	06009	3	93991	33
28	4 16	55 44	69189	10	30811	75205	14	24795	06016	3	93984	32
29	4 8	55 52	69212	11	30788	75235	14	24765	06023	3	93977	31
30	8 4 0	3 56 0	9.69234	11	10.30766	9.75264	15	10.24736	10.06030	4	9.93970	30
31	3 52	56 8	69256	12	30744	75294	15	24706	06037	4	93963	29
32	3 44	56 16	69279	12	30721	75323	16	24677	06045	4	93955	28
33	3 36	56 24	69301	12	30699	75353	16	24647	06052	4	93948	27
34	3 28	56 32	69323	13	30677	75382	17	24618	06059	4	93941	26
35	8 3 20	3 56 40	9.69345	13	10.30655	9.75411	17	10.24589	10.06066	4	9.93934	25
36	3 12	56 48	69368	13	30632	75441	18	24559	06073	4	93927	24
37	3 4	56 56	69390	14	30610	75470	18	24530	06080	4	93920	23
38	2 56	57 4	69412	14	30588	75500	19	24500	06088	5	93912	22
39	2 48	57 12	69434	15	30566	75529	19	24471	06095	5	93905	21
40	8 2 40	3 57 20	9.69456	15	10.30544	9.75558	20	10.24442	10.06102	5	9.93898	20
41	2 32	57 28	69479	15	30521	75588	20	24412	06109	5	93891	19
42	2 24	57 36	69501	16	30499	75617	21	24383	06116	5	93884	18
43	2 16	57 44	69523	16	30477	75647	21	24353	06124	5	93876	17
44	2 8	57 52	69545	16	30455	75676	22	24324	06131	5	93869	16
45	8 2 0	3 58 0	9.69567	17	10.30433	9.75705	22	10.24295	10.06138	5	9.93862	15
46	1 52	58 8	69589	17	30411	75735	23	24265	06145	5	93855	14
47	1 44	58 16	69611	17	30389	75764	23	24236	06153	6	93847	13
48	1 36	58 24	69633	18	30367	75793	24	24207	06160	6	93840	12
49	1 28	58 32	69655	18	30345	75822	24	24178	06167	6	93833	11
50	8 1 20	3 58 40	9.69677	19	10.30323	9.75852	25	10.24148	10.06174	6	9.93826	10
51	1 12	58 48	69699	19	30301	75881	25	24119	06181	6	93819	9
52	1 4	58 56	69721	19	30279	75910	26	24090	06189	6	93811	8
53	0 56	59 4	69743	20	30257	75939	26	24061	06196	6	93804	7
54	0 48	59 12	69765	20	30235	75969	27	24031	06203	6	93797	6
55	8 0 40	3 59 20	9.69787	20	10.30213	9.75998	27	10.24002	10.06211	7	9.93789	5
56	0 32	59 28	69809	21	30191	76027	28	23973	06218	7	93782	4
57	0 24	59 36	69831	21	30169	76056	28	23944	06225	7	93775	3
58	0 16	59 44	69853	22	30147	76086	29	23914	06232	7	93768	2
59	0 8	59 52	69875	22	30125	76115	29	23885	06240	7	93760	1
60	0 0	4 0 0	69897	22	30103	76144	29	23856	06247	7	93753	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

119° A A B B C C 60°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	3	6	8	11	14	17	20
	B	4	7	11	15	18	22	26
	C	1	2	3	4	4	5	6

Digitized by Google

TABLE XXVII.

S. **Log. Sines, Tangents, and Secants.** G'.

30°			A		A	B		B	C		C	149°
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff	Cotangent	Secant.	Diff.	Cosine.	M
0	8 0 0	4 0 0	9.69897	0	10.30103	9.76144	0	10.23856	10.06247	0	9.93753	60
1	7 59 52	0 8	69919	0	30081	76173	0	23827	06254	0	93746	59
2	59 44	0 16	69941	1	30059	76202	1	23798	06262	0	93738	58
3	59 36	0 24	69963	1	30037	76231	1	23769	06269	0	93731	57
4	59 28	0 32	69984	1	30016	76261	2	23739	06276	0	93724	56
5	7 59 20	4 0 40	9.70006	2	10.29994	9.76290	2	10.23710	10.06283	1	9.93717	55
6	59 12	0 48	70028	2	29972	76319	3	23681	06291	1	93709	54
7	59 4	0 56	70050	3	29950	76348	3	23652	06298	1	93702	53
8	58 56	1 4	70072	3	29928	76377	4	23623	06305	1	93695	52
9	58 48	1 12	70093	3	29907	76406	4	23594	06313	1	93687	51
10	7 58 40	4 1 20	9.70115	4	10.29885	9.76435	5	10.23565	10.06320	1	9.93680	50
11	58 32	1 28	70137	4	29863	76464	5	23536	06327	1	93673	49
12	58 24	1 36	70159	4	29841	76493	6	23507	06335	1	93665	48
13	58 16	1 44	70180	5	29820	76522	6	23478	06342	2	93658	47
14	58 8	1 52	70202	5	29798	76551	7	23449	06350	2	93650	46
15	7 58 0	4 2 0	9.70224	5	10.29776	9.76580	7	10.23420	10.06357	2	9.93643	45
16	57 52	2 8	70245	6	29755	76609	8	23391	06364	2	93636	44
17	57 44	2 16	70267	6	29733	76639	8	23361	06372	2	93628	43
18	57 36	2 24	70288	6	29712	76668	9	23332	06379	2	93621	42
19	57 28	2 32	70310	7	29690	76697	9	23303	06386	2	93614	41
20	7 57 20	4 2 40	9.70332	7	10.29668	9.76725	10	10.23275	10.06394	2	9.93606	40
21	57 12	2 48	70353	8	29647	76754	10	23246	06401	3	93599	39
22	57 4	2 56	70375	8	29625	76783	11	23217	06409	3	93591	38
23	56 56	3 4	70396	8	29604	76812	11	23188	06416	3	93584	37
24	56 48	3 12	70418	9	29582	76841	12	23159	06423	3	93577	36
25	7 56 40	4 3 20	9.70439	9	10.29561	9.76870	12	10.23130	10.06431	3	9.93569	35
26	56 32	3 28	70461	9	29539	76899	13	23101	06438	3	93562	34
27	56 24	3 36	70482	10	29518	76928	13	23072	06446	3	93554	33
28	56 16	3 44	70504	10	29496	76957	13	23043	06453	3	93547	32
29	56 8	3 52	70525	10	29475	76986	14	23014	06461	4	93539	31
30	7 56 0	4 4 0	9.70547	11	10.29453	9.77015	14	10.22985	10.06468	4	9.93532	30
31	55 52	4 8	70568	11	29432	77044	15	22956	06475	4	93525	29
32	55 44	4 16	70590	11	29410	77073	15	22927	06483	4	93517	28
33	55 36	4 24	70611	12	29389	77101	16	22899	06490	4	93510	27
34	55 28	4 32	70633	12	29367	77130	16	22870	06498	4	93502	26
35	7 55 20	4 4 40	9.70654	13	10.29346	9.77159	17	10.22841	10.06505	4	9.93495	25
36	55 12	4 48	70675	13	29325	77188	17	22812	06513	4	93487	24
37	55 4	4 56	70697	13	29303	77217	18	22783	06520	5	93480	23
38	54 56	5 4	70718	14	29282	77246	18	22754	06528	5	93472	22
39	54 48	5 12	70739	14	29261	77274	19	22726	06535	5	93465	21
40	7 54 40	4 5 20	9.70761	14	10.29239	9.77303	19	10.22697	10.06543	5	9.93457	20
41	54 32	5 28	70782	15	29218	77332	20	22668	06550	5	93450	19
42	54 24	5 36	70803	15	29197	77361	20	22639	06558	5	93442	18
43	54 16	5 44	70824	15	29176	77390	21	22610	06565	5	93435	17
44	54 8	5 52	70846	16	29154	77418	21	22582	06573	5	93427	16
45	7 54 0	4 6 0	9.70867	16	10.29133	9.77447	22	10.22553	10.06580	6	9.93420	15
46	53 52	6 8	70888	16	29112	77476	22	22524	06588	6	93412	14
47	53 44	6 16	70909	17	29091	77505	23	22495	06595	6	93405	13
48	53 36	6 24	70931	17	29069	77533	23	22467	06603	6	93397	12
49	53 28	6 32	70952	18	29048	77562	24	22438	06610	6	93390	11
50	7 53 20	4 6 40	9.70973	18	10.29027	9.77591	24	10.22409	10.06618	6	9.93382	10
51	53 12	6 48	70994	18	29006	77619	25	22381	06625	6	93375	9
52	53 4	6 56	71015	19	28985	77648	25	22352	06633	6	93367	8
53	52 56	7 4	71036	19	28964	77677	26	22323	06640	7	93360	7
54	52 48	7 12	71058	19	28942	77706	26	22294	06648	7	93352	6
55	7 52 40	4 7 20	9.71079	20	10.28921	9.77734	26	10.22266	10.06656	7	9.93344	5
56	52 32	7 28	71100	20	28900	77763	27	22237	06663	7	93337	4
57	52 24	7 36	71121	20	28879	77791	27	22209	06671	7	93329	3
58	52 16	7 44	71142	21	28858	77820	28	22180	06678	7	93322	2
59	52 8	7 52	71163	21	28837	77849	28	22151	06686	7	93314	1
60	52 0	8 0	71184	21	28816	77877	29	22123	06693	7	93307	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
120°			A		A	B		B	C		C	59°

Seconds of time		1	2	3	4	5	6	7
Prop. parts of cols.	A	3	5	8	11	13	16	19
	B	4	7	11	14	18	22	25
	C	1	2	3	4	5	6	7

Digitized by Google

TABLE XXVII.

S'. Log. Sines, Tangents, and Secants. G'

31°			A		A	B		B	C		C	148°
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	7 52 0	4 8 0	9.71184	0	10.28816	9.77877	0	10.22123	10.06693	0	9.93307	60
1	51 52	8 8	71205	0	28795	77906	0	22094	06701	0	93299	59
2	51 44	8 16	71226	1	28774	77935	1	22065	06709	0	93291	58
3	51 36	8 24	71247	1	28753	77963	1	22037	06716	0	93284	57
4	51 28	8 32	71268	1	28732	77992	2	22008	06724	1	93276	56
5	7 51 20	4 8 40	9.71289	2	10.28711	9.78020	2	10.21980	10.06731	1	9.93269	55
6	51 12	8 48	71310	2	28690	78049	3	21951	06739	1	93261	54
7	51 4	8 56	71331	2	28669	78077	3	21923	06747	1	93253	53
8	50 56	9 4	71352	3	28648	78106	4	21894	06754	1	93246	52
9	50 48	9 12	71373	3	28627	78135	4	21865	06762	1	93238	51
10	7 50 40	4 9 20	9.71393	3	10.28607	9.78163	5	10.21837	10.06770	1	9.93230	50
11	50 32	9 28	71414	4	28586	78192	5	21808	06777	1	93223	49
12	50 24	9 36	71435	4	28565	78220	6	21780	06785	2	93215	48
13	50 16	9 44	71456	4	28544	78249	6	21751	06793	2	93207	47
14	50 8	9 52	71477	5	28523	78277	7	21723	06800	2	93200	46
15	7 50 0	4 10 0	9.71498	5	10.28502	9.78306	7	10.21694	10.06808	2	9.93192	45
16	49 52	10 8	71519	5	28481	78334	8	21666	06816	2	93184	44
17	49 44	10 16	71539	6	28461	78363	8	21637	06823	2	93177	43
18	49 36	10 24	71560	6	28440	78391	9	21609	06831	2	93169	42
19	49 28	10 32	71581	7	28419	78419	9	21581	06839	2	93161	41
20	7 49 20	4 10 40	9.71602	7	10.28398	9.78448	9	10.21552	10.06846	3	9.93154	40
21	49 12	10 48	71622	7	28378	78476	10	21524	06854	3	93146	39
22	49 4	10 56	71643	8	28357	78505	10	21495	06862	3	93138	38
23	48 56	11 4	71664	8	28336	78533	11	21467	06869	3	93131	37
24	48 48	11 12	71685	8	28315	78562	11	21438	06877	3	93123	36
25	7 48 40	4 11 20	9.71705	9	10.28295	9.78590	12	10.21410	10.06885	3	9.93115	35
26	48 32	11 28	71726	9	28274	78618	12	21382	06892	3	93108	34
27	48 24	11 36	71747	9	28253	78647	13	21353	06900	3	93100	33
28	48 16	11 44	71767	10	28233	78675	13	21325	06908	4	93092	32
29	48 8	11 52	71788	10	28212	78704	14	21296	06916	4	93084	31
30	7 48 0	4 12 0	9.71809	10	10.28191	9.78732	14	10.21268	10.06923	4	9.93077	30
31	47 52	12 8	71829	11	28171	78760	15	21240	06931	4	93069	29
32	47 44	12 16	71850	11	28150	78789	15	21211	06939	4	93061	28
33	47 36	12 24	71870	11	28130	78817	16	21183	06947	4	93053	27
34	47 28	12 32	71891	12	28109	78845	16	21155	06954	4	93046	26
35	7 47 20	4 12 40	9.71911	12	10.28089	9.78874	17	10.21126	10.06962	5	9.93038	25
36	47 12	12 48	71932	12	28068	78902	17	21098	06970	5	93030	24
37	47 4	12 56	71952	13	28048	78930	17	21070	06978	5	93022	23
38	46 56	13 4	71973	13	28027	78959	18	21041	06986	5	93014	22
39	46 48	13 12	71994	13	28006	78987	18	21013	06993	5	93007	21
40	7 46 40	4 13 20	9.72014	14	10.27986	9.79015	19	10.20985	10.07001	5	9.92999	20
41	46 32	13 28	72034	14	27966	79043	19	20957	07009	5	92991	19
42	46 24	13 36	72055	14	27945	79072	20	20928	07017	5	92983	18
43	46 16	13 44	72075	15	27925	79100	20	20900	07024	6	92976	17
44	46 8	13 52	72096	15	27904	79128	21	20872	07032	6	92968	16
45	7 46 0	4 14 0	9.72116	15	10.27884	9.79156	21	10.20844	10.07040	6	9.92960	15
46	45 52	14 8	72137	16	27863	79185	22	20815	07048	6	92952	14
47	45 44	14 16	72157	16	27843	79213	22	20787	07056	6	92944	13
48	45 36	14 24	72177	16	27823	79241	23	20759	07064	6	92936	12
49	45 28	14 32	72198	17	27802	79269	23	20731	07071	6	92929	11
50	7 45 20	4 14 40	9.72218	17	10.27782	9.79297	24	10.20703	10.07079	6	9.92921	10
51	45 12	14 48	72238	18	27762	79326	24	20674	07087	7	92913	9
52	45 4	14 56	72259	18	27741	79354	25	20646	07095	7	92905	8
53	44 56	15 4	72279	18	27721	79382	25	20618	07103	7	92897	7
54	44 48	15 12	72299	19	27701	79410	26	20590	07111	7	92889	6
55	7 44 40	4 15 20	9.72320	19	10.27680	9.79438	26	10.20562	10.07119	7	9.92881	5
56	44 32	15 28	72340	19	27660	79466	26	20534	07126	7	92874	4
57	44 24	15 36	72360	20	27640	79495	27	20505	07134	7	92866	3
58	44 16	15 44	72381	20	27619	79523	27	20477	07142	7	92858	2
59	44 8	15 52	72401	20	27599	79551	28	20449	07150	8	92850	1
60	44 0	16 0	72421	21	27579	79579	28	20421	07158	8	92842	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
121°			A		A	B		B	C		C	58°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols	A	3	5	8	10	13	15	18
	B	4	7	11	14	18	21	25
	C	1	2	3	4	5	6	7

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

S'. 32°			A		A	B		B	C		C	G. 147°
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	7 44 0	4 16 0	9.72421	0	10.27579	9.79579	0	10.20421	10.07158	0	9.92842	60
1	43 52	16 8	72441	0	27559	79607	0	20393	07166	0	92834	59
2	43 44	16 16	72461	1	27539	79635	1	20365	07174	0	92826	58
3	43 36	16 24	72482	1	27518	79663	1	20337	07182	0	92818	57
4	43 28	16 32	72502	1	27498	79691	2	20309	07190	1	92810	56
5	7 43 20	4 16 40	9.72522	2	10.27478	9.79719	2	10.20281	10.07197	1	9.92803	55
6	43 12	16 48	72542	2	27458	79747	3	20253	07205	1	92795	54
7	43 4	16 56	72562	2	27438	79776	3	20224	07213	1	92787	53
8	42 56	17 4	72582	3	27418	79804	4	20196	07221	1	92779	52
9	42 48	17 12	72602	3	27398	79832	4	20168	07229	1	92771	51
10	7 42 40	4 17 20	9.72622	3	10.27378	9.79860	5	10.20140	10.07237	1	9.92763	50
11	42 32	17 28	72643	4	27357	79888	5	20112	07245	1	92755	49
12	42 24	17 36	72663	4	27337	79916	6	20084	07253	2	92747	48
13	42 16	17 44	72683	4	27317	79944	6	20056	07261	2	92739	47
14	42 8	17 52	72703	5	27297	79972	7	20028	07269	2	92731	46
15	7 42 0	4 18 0	9.72723	5	10.27277	9.80000	7	10.20000	10.07277	2	9.92723	45
16	41 52	18 8	72743	5	27257	80028	7	19972	07285	2	92715	44
17	41 44	18 16	72763	6	27237	80056	8	19944	07293	2	92707	43
18	41 36	18 24	72783	6	27217	80084	8	19916	07301	2	92699	42
19	41 28	18 32	72803	6	27197	80112	9	19888	07309	3	92691	41
20	7 41 20	4 18 40	9.72823	7	10.27177	9.80140	9	10.19860	10.07317	3	9.92683	40
21	41 12	18 48	72843	7	27157	80168	10	19832	07325	3	92675	39
22	41 4	18 56	72863	7	27137	80195	10	19805	07333	3	92667	38
23	40 56	19 4	72883	8	27117	80223	11	19777	07341	3	92659	37
24	40 48	19 12	72902	8	27098	80251	11	19749	07349	3	92651	36
25	7 40 40	4 19 20	9.72922	8	10.27078	9.80279	12	10.19721	10.07357	3	0.92643	35
26	40 32	19 28	72942	9	27058	80307	12	19693	07365	3	92635	34
27	40 24	19 36	72962	9	27038	80335	13	19665	07373	4	92627	33
28	40 16	19 44	72982	9	27018	80363	13	19637	07381	4	92619	32
29	40 8	19 52	73002	10	26998	80391	13	19609	07389	4	92611	31
30	7 40 0	4 20 0	9.73022	10	10.26978	9.80419	14	10.19581	10.07397	4	9.92603	30
31	39 52	20 8	73041	10	26959	80447	14	19553	07405	4	92595	29
32	39 44	20 16	73061	11	26939	80474	15	19526	07413	4	92587	28
33	39 36	20 24	73081	11	26919	80502	15	19498	07421	4	92579	27
34	39 28	20 32	73101	11	26899	80530	16	19470	07429	5	92571	26
35	7 39 20	4 20 40	9.73121	12	10.26879	9.80558	16	10.19442	10.07437	5	9 92563	25
36	39 12	20 48	73140	12	26860	80586	17	19414	07445	5	92555	24
37	39 4	20 56	73160	12	26840	80614	17	19386	07454	5	92546	23
38	38 56	21 4	73180	13	26820	80642	18	19358	07462	5	92538	22
39	38 48	21 12	73200	13	26800	80669	18	19331	07470	5	92530	21
40	7 38 40	4 21 20	9.73219	13	10.26781	9.80697	19	10.19303	10.07478	5	9 92522	20
41	38 32	21 28	73239	14	26761	80725	19	19275	07486	6	92514	19
42	38 24	21 36	73259	14	26741	80753	20	19247	07494	6	92506	18
43	38 16	21 44	73278	14	26722	80781	20	19219	07502	6	92498	17
44	38 8	21 52	73298	15	26702	80808	20	19192	07510	6	92490	16
45	7 38 0	4 22 0	9.73318	15	10.26682	9.80836	21	10.19164	10.07518	6	9.92482	15
46	37 52	22 8	73337	15	26663	80864	21	19136	07527	6	92473	14
47	37 44	22 16	73357	16	26643	80892	22	19108	07535	6	92465	13
48	37 36	22 24	73377	16	26623	80919	22	19081	07543	6	92457	12
49	37 28	22 32	73396	16	26604	80947	23	19053	07551	7	92449	11
50	7 37 20	4 22 40	9.73416	17	10.26584	9.80975	23	10.19025	10.07559	7	9.92441	10
51	37 12	22 48	73435	17	26565	81003	24	18997	07567	7	92433	9
52	37 4	22 56	73455	17	26545	81030	24	18970	07575	7	92425	8
53	36 56	23 4	73474	18	26526	81058	25	18942	07584	7	92416	7
54	36 48	23 12	73494	18	26506	81086	25	18914	07592	7	92408	6
55	7 36 40	4 23 20	9.73513	18	10.26487	9.81113	26	10.18887	10.07600	7	9.92400	5
56	36 32	23 28	73533	19	26467	81141	26	18859	07608	8	92392	4
57	36 24	23 36	73552	19	26448	81169	26	18831	07616	8	92384	3
58	36 16	23 44	73572	19	26428	81196	27	18804	07624	8	92376	2
59	36 8	23 52	73591	20	26409	81224	27	18776	07633	8	92367	1
60	36 0	24 0	73611	20	26389	81252	28	18748	07641	8	92359	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
122°			A		A	B		B	C		C	57°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	2	5	7	10	12	15	17
	B	3	7	10	14	17	21	24
	C	1	2	3	4	5	6	7

Digitized by Google

TABLE XXVII.

S. Log. Sines, Tangents, and Secants. G.

33° A A B B C C 146°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	7 36 0	4 24 0	9.73611	0	10.26389	9.81252	0	10.18748	10.07641	0	9.92359	60
1	35 52	24 8	73630	0	26370	81279	0	18721	07649	0	92351	59
2	35 44	24 16	73650	1	26350	81307	1	18693	07657	0	92343	58
3	35 36	24 24	73669	1	26331	81335	1	18665	07665	0	92335	57
4	35 28	24 32	73689	1	26311	81362	2	18638	07674	1	92326	56
5	7 35 20	4 24 40	9.73708	2	10.26292	9.81390	2	10.18610	10.07682	1	9.92318	55
6	35 12	24 48	73727	2	26273	81418	3	18582	07690	1	92310	54
7	35 4	24 56	73747	2	26253	81445	3	18555	07698	1	92302	53
8	34 56	25 4	73766	3	26234	81473	4	18527	07707	1	92293	52
9	34 48	25 12	73785	3	26215	81500	4	18500	07715	1	92285	51
10	7 34 40	4 25 20	9.73805	3	10.26195	9.81528	5	10.18472	10.07723	1	9.92277	50
11	34 32	25 28	73824	3	26176	81556	5	18444	07731	2	92269	49
12	34 24	25 36	73843	4	26157	81583	5	18417	07740	2	92260	48
13	34 16	25 44	73863	4	26137	81611	6	18389	07748	2	92252	47
14	34 8	25 52	73882	4	26118	81638	6	18362	07756	2	92244	46
15	7 34 0	4 26 0	9.73901	5	10.26099	9.81666	7	10.18334	10.07765	2	9.92235	45
16	33 52	26 8	73921	5	26079	81693	7	18307	07773	2	92227	44
17	33 44	26 16	73940	5	26060	81721	8	18279	07781	2	92219	43
18	33 36	26 24	73959	6	26041	81748	8	18252	07789	3	92211	42
19	33 28	26 32	73978	6	26022	81776	9	18224	07798	3	92202	41
20	7 33 20	4 26 40	9.73997	6	10.26003	9.81803	9	10.18197	10.07806	3	9.92194	40
21	33 12	26 48	74017	7	25983	81831	10	18169	07814	3	92186	39
22	33 4	26 56	74036	7	25964	81858	10	18142	07823	3	92177	38
23	32 56	27 4	74055	7	25945	81886	11	18114	07831	3	92169	37
24	32 48	27 12	74074	8	25926	81913	11	18087	07839	3	92161	36
25	7 32 40	4 27 20	9.74093	8	10.25907	9.81941	11	10.18059	10.07848	3	9.92152	35
26	32 32	27 28	74113	8	25887	81968	12	18032	07856	4	92144	34
27	32 24	27 36	74132	9	25868	81996	12	18004	07864	4	92136	33
28	32 16	27 44	74151	9	25849	82023	13	17977	07873	4	92127	32
29	32 8	27 52	74170	9	25830	82051	13	17949	07881	4	92119	31
30	7 32 0	4 28 0	9.74189	10	10.25811	9.82078	14	10.17922	10.07889	4	9.92111	30
31	31 52	28 8	74208	10	25792	82106	14	17894	07898	4	92102	29
32	31 44	28 16	74227	10	25773	82133	15	17867	07906	4	92094	28
33	31 36	28 24	74246	10	25754	82161	15	17839	07914	5	92086	27
34	31 28	28 32	74265	11	25735	82188	16	17812	07923	5	92077	26
35	7 31 20	4 28 40	9.74284	11	10.25716	9.82215	16	10.17785	10.07931	5	9.92069	25
36	31 12	28 48	74303	11	25697	82243	16	17757	07940	5	92060	24
37	31 4	28 56	74322	12	25678	82270	17	17730	07948	5	92052	23
38	30 56	29 4	74341	12	25659	82298	17	17702	07956	5	92044	22
39	30 48	29 12	74360	12	25640	82325	18	17675	07965	5	92035	21
40	7 30 40	4 29 20	9.74379	13	10.25621	9.82352	18	10.17648	10.07973	6	9.92027	20
41	30 32	29 28	74398	13	25602	82380	19	17620	07982	6	92018	19
42	30 24	29 36	74417	13	25583	82407	19	17593	07990	6	92010	18
43	30 16	29 44	74436	14	25564	82435	20	17565	07998	6	92002	17
44	30 8	29 52	74455	14	25545	82462	20	17538	08007	6	91993	16
45	7 30 0	4 30 0	9.74474	14	10.25526	9.82489	21	10.17511	10.08015	6	9.91985	15
46	29 52	30 8	74493	15	25507	82517	21	17483	08024	6	91976	14
47	29 44	30 16	74512	15	25488	82544	22	17456	08032	7	91968	13
48	29 36	30 24	74531	15	25469	82571	22	17429	08041	7	91959	12
49	29 28	30 32	74549	16	25451	82599	22	17401	08049	7	91951	11
50	7 29 20	4 30 40	9.74568	16	10.25432	9.82626	23	10.17374	10.08058	7	9.91942	10
51	29 12	30 48	74587	16	25413	82653	23	17347	08066	7	91934	9
52	29 4	30 56	74606	17	25394	82681	24	17319	08075	7	91925	8
53	28 56	31 4	74625	17	25375	82708	24	17292	08083	7	91917	7
54	28 48	31 12	74644	17	25356	82735	25	17265	08092	8	91908	6
55	7 28 40	4 31 20	9.74662	17	10.25338	9.82762	25	10.17238	10.08100	8	9.91900	5
56	28 32	31 28	74681	18	25319	82790	26	17210	08109	8	91891	4
57	28 24	31 36	74700	18	25300	82817	26	17183	08117	8	91883	3
58	28 16	31 44	74719	18	25281	82844	27	17156	08126	8	91874	2
59	28 8	31 52	74737	19	25263	82871	27	17129	08134	8	91866	1
60	28 0	32 0	74756	19	25244	82899	27	17101	08143	8	91857	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

123° A A B B C C 56°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	5	7	10	12	14	17
	B	3	7	10	14	17	21	24
	C	1	2	3	4	5	6	7

Digitized by Google

TABLE XXVII

Log. Sines, Tangents, and Secants.

S. 34°			A		A	B		B	C		C 145° G'.	
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine	M
0	7 28 0	4 32 0	9.74756	0	10.25244	9.82899	0	10.17101	10.08143	0	9.91857	60
1	27 52	32 8	74775	0	25225	82926	0	17074	08151	0	91849	59
2	27 44	32 16	74794	1	25206	82953	1	17047	08160	0	91840	58
3	27 36	32 24	74812	1	25188	82980	1	17020	08168	0	91832	57
4	27 28	32 32	74831	1	25169	83008	2	16992	08177	1	91823	56
5	7 27 20	4 32 40	9.74850	2	10.25150	9.83035	2	10.16965	10.08185	1	9.91815	55
6	27 12	32 48	74868	2	25132	83062	3	16938	08194	1	91806	54
7	27 4	32 56	74887	2	25113	83089	3	16911	08202	1	91798	53
8	26 56	33 4	74906	2	25094	83117	4	16883	08211	1	91789	52
9	26 48	33 12	74924	3	25076	83144	4	16856	08219	1	91781	51
10	7 26 40	4 33 20	9.74943	3	10.25057	9.83171	5	10.16829	10.08228	1	9.91772	50
11	26 32	33 28	74961	3	25039	83198	5	16802	08237	2	91763	49
12	26 24	33 36	74980	4	25020	83225	5	16775	08245	2	91755	48
13	26 16	33 44	74999	4	25001	83252	6	16748	08254	2	91746	47
14	26 8	33 52	75017	4	24983	83280	6	16720	08262	2	91738	46
15	7 26 0	4 34 0	9.75036	5	10.24964	9.83307	7	10.16693	10.08271	2	9.91729	45
16	25 52	34 8	75054	5	24946	83334	7	16666	08280	2	91720	44
17	25 44	34 16	75073	5	24927	83361	8	16639	08288	2	91712	43
18	25 36	34 24	75091	6	24909	83388	8	16612	08297	3	91703	42
19	25 28	34 32	75110	6	24890	83415	9	16585	08305	3	91695	41
20	7 25 20	4 34 40	9.75128	6	10.24872	9.83442	9	10.16558	10.08314	3	9.91686	40
21	25 12	34 48	75147	6	24853	83470	9	16530	08323	3	91677	39
22	25 4	34 56	75165	7	24835	83497	10	16503	08331	3	91669	38
23	24 56	35 4	75184	7	24816	83524	10	16476	08340	3	91660	37
24	24 48	35 12	75202	7	24798	83551	11	16449	08349	3	91651	36
25	7 24 40	4 35 20	9.75221	8	10.24779	9.83578	11	10.16422	10.08357	4	9.91643	35
26	24 32	35 28	75239	8	24761	83605	12	16395	08366	4	91634	34
27	24 24	35 36	75258	8	24742	83632	12	16368	08375	4	91625	33
28	24 16	35 44	75276	9	24724	83659	13	16341	08383	4	91617	32
29	24 8	35 52	75294	9	24706	83686	13	16314	08392	4	91608	31
30	7 24 0	4 36 0	9.75313	9	10.24687	9.83713	14	10.16287	10.08401	4	9.91599	30
31	23 52	36 8	75331	9	24669	83740	14	16260	08409	4	91591	29
32	23 44	36 16	75350	10	24650	83768	14	16232	08418	5	91582	28
33	23 36	36 24	75368	10	24632	83795	15	16205	08427	5	91573	27
34	23 28	36 32	75386	10	24614	83822	15	16178	08435	5	91565	26
35	7 23 20	4 36 40	9.75405	11	10.24595	9.83849	16	10.16151	10.08444	5	9.91556	25
36	23 12	36 48	75423	11	24577	83876	16	16124	08453	5	91547	24
37	23 4	36 56	75441	11	24559	83903	17	16097	08462	5	91538	23
38	22 56	37 4	75459	12	24541	83930	17	16070	08470	5	91530	22
39	22 48	37 12	75478	12	24522	83957	18	16043	08479	6	91521	21
40	7 22 40	4 37 20	9.75496	12	10.24504	9.83984	18	10.16016	10.08488	6	9.91512	20
41	22 32	37 28	75514	13	24486	84011	18	15989	08496	6	91504	19
42	22 24	37 36	75533	13	24467	84038	19	15962	08505	6	91495	18
43	22 16	37 44	75551	13	24449	84065	19	15935	08514	6	91486	17
44	22 8	37 52	75569	13	24431	84092	20	15908	08523	6	91477	16
45	7 22 0	4 38 0	9.75587	14	10.24413	9.84119	20	10.15881	10.08531	7	9.91469	15
46	21 52	38 8	75605	14	24395	84146	21	15854	08540	7	91460	14
47	21 44	38 16	75624	14	24376	84173	21	15827	08549	7	91451	13
48	21 36	38 24	75642	15	24358	84200	22	15800	08558	7	91442	12
49	21 28	38 32	75660	15	24340	84227	22	15773	08567	7	91433	11
50	7 21 20	4 38 40	9.75678	15	10.24322	9.84254	23	10.15746	10.08575	7	9.91425	10
51	21 12	38 48	75696	16	24304	84280	23	15720	08584	7	91416	9
52	21 4	38 56	75714	16	24286	84307	23	15693	08593	8	91407	8
53	20 56	39 4	75733	16	24267	84334	24	15666	08602	8	91398	7
54	20 48	39 12	75751	17	24249	84361	24	15639	08611	8	91389	6
55	7 20 40	4 39 20	9.75769	17	10.24231	9.84388	25	10.15612	10.08619	8	9.91381	5
56	20 32	39 28	75787	17	24213	84415	25	15585	08628	8	91372	4
57	20 24	39 36	75805	17	24195	84442	26	15558	08637	8	91363	3
58	20 16	39 44	75823	18	24177	84469	26	15531	08646	8	91354	2
59	20 8	39 52	75841	18	24159	84496	27	15504	08655	9	91345	1
60	20 0	40 0	75859	18	24141	84523	27	15477	08664	9	91336	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
124°			A		A	B		B	C		C 55	

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	5	7	9	11	14	16
	B	3	7	10	14	17	20	24
	C	1	2	3	4	5	7	8

Digitized by Google

TABLE XXVII.

S'. G

Log. Sines, Tangents, and Secants.

35° A A B B C C 144°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	7 20 0	4 40 0	9.75859	0	10.24141	9.84523	0	10.15477	10.08664	0	9.91336	60
1	19 52	40 8	75877	0	24123	84550	0	15450	08672	0	91328	59
2	19 44	40 16	75895	1	24105	84576	1	15424	08681	0	91319	58
3	19 36	40 24	75913	1	24087	84603	1	15397	08690	0	91310	57
4	19 28	40 32	75931	1	24069	84630	2	15370	08699	1	91301	56
5	7 19 20	4 40 40	9.75949	1	10.24051	9.84657	2	10.15343	10.08708	1	9.91292	55
6	19 12	40 48	75967	2	24033	84684	3	15316	08717	1	91283	54
7	19 4	40 56	75985	2	24015	84711	3	15289	08726	1	91274	53
8	18 56	41 4	76003	2	23997	84738	4	15262	08734	1	91266	52
9	18 48	41 12	76021	3	23979	84764	4	15236	08743	1	91257	51
10	7 18 40	4 41 20	9.76039	3	10.23961	9.84791	4	10.15209	10.08752	2	9.91248	50
11	18 32	41 28	76057	3	23943	84818	5	15182	08761	2	91239	49
12	18 24	41 36	76075	4	23925	84845	5	15155	08770	2	91230	48
13	18 16	41 44	76093	4	23907	84872	6	15128	08779	2	91221	47
14	18 8	41 52	76111	4	23889	84899	6	15101	08788	2	91212	46
15	7 18 0	4 42 0	9.76129	4	10.23871	9.84925	7	10.15075	10.08797	2	9.91203	45
16	17 52	42 8	76146	5	23854	84952	7	15048	08806	2	91194	44
17	17 44	42 16	76164	5	23836	84979	8	15021	08815	3	91185	43
18	17 36	42 24	76182	5	23818	85006	8	14994	08824	3	91176	42
19	17 28	42 32	76200	6	23800	85033	8	14967	08833	3	91167	41
20	7 17 20	4 42 40	9.76218	6	10.23782	9.85059	9	10.14941	10.08842	3	9.91158	40
21	17 12	42 48	76236	6	23764	85086	9	14914	08851	3	91149	39
22	17 4	42 56	76253	6	23747	85113	10	14887	08859	3	91141	38
23	16 56	43 4	76271	7	23729	85140	10	14860	08868	3	91132	37
24	16 48	43 12	76289	7	23711	85166	11	14834	08877	4	91123	36
25	7 16 40	4 43 20	9.76307	7	10.23693	9.85193	11	10.14807	10.08886	4	9.91114	35
26	16 32	43 28	76324	8	23676	85220	12	14780	08895	4	91105	34
27	16 24	43 36	76342	8	23658	85247	12	14753	08904	4	91096	33
28	16 16	43 44	76360	8	23640	85273	12	14727	08913	4	91087	32
29	16 8	43 52	76378	9	23622	85300	13	14700	08922	4	91078	31
30	7 16 0	4 44 0	9.76395	9	10.23605	9.85327	13	10.14673	10.08931	5	9.91069	30
31	15 52	44 8	76413	9	23587	85354	14	14646	08940	5	91060	29
32	15 44	44 16	76431	9	23569	85380	14	14620	08949	5	91051	28
33	15 36	44 24	76448	10	23552	85407	15	14593	08958	5	91042	27
34	15 28	44 32	76466	10	23534	85434	15	14566	08967	5	91033	26
35	7 15 20	4 44 40	9.76484	10	10.23516	9.85460	16	10.14540	10.08977	5	9.91023	25
36	15 12	44 48	76501	11	23499	85487	16	14513	08986	5	91014	24
37	15 4	44 56	76519	11	23481	85514	16	14486	08995	6	91005	23
38	14 56	45 4	76537	11	23463	85540	17	14460	09004	6	90996	22
39	14 48	45 12	76554	12	23446	85567	17	14433	09013	6	90987	21
40	7 14 40	4 45 20	9.76572	12	10.23428	9.85594	18	10.14406	10.09022	6	9.90978	20
41	14 32	45 28	76590	12	23410	85620	18	14380	09031	6	90969	19
42	14 24	45 36	76607	12	23393	85647	19	14353	09040	6	90960	18
43	14 16	45 44	76625	13	23375	85674	19	14326	09049	6	90951	17
44	14 8	45 52	76642	13	23358	85700	20	14300	09058	7	90942	16
45	7 14 0	4 46 0	9.76660	13	10.23340	9.85727	20	10.14273	10.09067	7	9.90933	15
46	13 52	46 8	76677	14	23323	85754	20	14246	09076	7	90924	14
47	13 44	46 16	76695	14	23305	85780	21	14220	09085	7	90915	13
48	13 36	46 24	76712	14	23288	85807	21	14193	09094	7	90906	12
49	13 28	46 32	76730	14	23270	85834	22	14166	09104	7	90896	11
50	7 13 20	4 46 40	9.76747	15	10.23253	9.85860	22	10.14140	10.09113	8	9.90887	10
51	13 12	46 48	76765	15	23235	85887	23	14113	09122	8	90878	9
52	13 4	46 56	76782	15	23218	85913	23	14087	09131	8	90869	8
53	12 56	47 4	76800	16	23200	85940	24	14060	09140	8	90860	7
54	12 48	47 12	76817	16	23183	85967	24	14033	09149	8	90851	6
55	7 12 40	4 47 20	9.76835	16	10.23165	9.85993	24	10.14007	10.09158	8	9.90842	5
56	12 32	47 28	76852	17	23148	86020	25	13980	09168	8	90832	4
57	12 24	47 36	76870	17	23130	86046	25	13954	09177	9	90823	3
58	12 16	47 44	76887	17	23113	86073	26	13927	09186	9	90814	2
59	12 8	47 52	76904	17	23096	86100	26	13900	09195	9	90805	1
60	12 0	48 0	76922	18	23078	86126	27	13874	09204	9	90796	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

125° A A B B C C 54°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	4	7	9	11	13	16
	B	3	7	10	13	17	20	23
	C	1	2	3	5	6	7	8

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

S'. G'.

36°			A		A	B		B	C		C	143°
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine	M
0	7 12 0	4 48 0	9.76922	0	10.23078	9.86126	0	10.13874	10.09204	0	9.90796	60
1	11 52	48 8	76939	0	23061	86153	0	13847	09213	0	90787	59
2	11 44	48 16	76957	1	23043	86179	1	13821	09223	0	90777	58
3	11 36	48 24	76974	1	23026	86206	1	13794	09232	0	90768	57
4	11 28	48 32	76991	1	23009	86232	2	13768	09241	1	90759	56
5	7 11 20	4 48 40	9.77009	1	10.22991	9.86259	2	10.13741	10.09250	1	9.90750	55
6	11 12	48 48	77026	2	22974	86285	3	13715	09259	1	90741	54
7	11 4	48 56	77043	2	22957	86312	3	13688	09269	1	90731	53
8	10 56	49 4	77061	2	22939	86338	4	13662	09278	1	90722	52
9	10 48	49 12	77078	3	22922	86365	4	13635	09287	1	90713	51
10	7 10 40	4 49 20	9.77095	3	10.22905	9.86392	4	10.13608	10.09296	2	9.90704	50
11	10 32	49 28	77112	3	22888	86418	5	13582	09306	2	90694	49
12	10 24	49 36	77130	3	22870	86445	5	13555	09315	2	90685	48
13	10 16	49 44	77147	4	22853	86471	6	13529	09324	2	90676	47
14	10 8	49 52	77164	4	22836	86498	6	13502	09333	2	90667	46
15	7 10 0	4 50 0	9.77181	4	10.22819	9.86524	7	10.13476	10.09343	2	9.90657	45
16	9 52	50 8	77199	5	22801	86551	7	13449	09352	2	90648	44
17	9 44	50 16	77216	5	22784	86577	7	13423	09361	3	90639	43
18	9 36	50 24	77233	5	22767	86603	8	13397	09370	3	90630	42
19	9 28	50 32	77250	5	22750	86630	8	13370	09380	3	90620	41
20	7 9 20	4 50 40	9.77268	6	10.22732	9.86656	9	10.13344	10.09389	3	9.90611	40
21	9 12	50 48	77285	6	22715	86683	9	13317	09398	3	90602	39
22	9 4	50 56	77302	6	22698	86709	10	13291	09408	3	90592	38
23	8 56	51 4	77319	7	22681	86736	10	13264	09417	4	90583	37
24	8 48	51 12	77336	7	22664	86762	11	13238	09426	4	90574	36
25	7 8 40	4 51 20	9.77353	7	10.22647	9.86789	11	10.13211	10.09435	4	9.90565	35
26	8 32	51 28	77370	7	22630	86815	11	13185	09445	4	90555	34
27	8 24	51 36	77387	8	22613	86842	12	13158	09454	4	90546	33
28	8 16	51 44	77405	8	22595	86868	12	13132	09463	4	90537	32
29	8 8	51 52	77422	8	22578	86894	13	13106	09473	5	90527	31
30	7 8 0	4 52 0	9.77439	9	10.22561	9.86921	13	10.13079	10.09482	5	9.90518	30
31	7 52	52 8	77456	9	22544	86947	14	13053	09491	5	90509	29
32	7 44	52 16	77473	9	22527	86974	14	13026	09501	5	90499	28
33	7 36	52 24	77490	9	22510	87000	15	13000	09510	5	90490	27
34	7 28	52 32	77507	10	22493	87027	15	12973	09520	5	90480	26
35	7 7 20	4 52 40	9.77524	10	10.22476	9.87053	15	10.12947	10.09529	5	9.90471	25
36	7 12	52 48	77541	10	22459	87079	16	12921	09538	6	90462	24
37	7 4	52 56	77558	11	22442	87106	16	12894	09548	6	90452	23
38	6 56	53 4	77575	11	22425	87132	17	12868	09557	6	90443	22
39	6 48	53 12	77592	11	22408	87158	17	12842	09566	6	90434	21
40	7 6 40	4 53 20	9.77609	11	10.22391	9.87185	18	10.12815	10.09576	6	9.90424	20
41	6 32	53 28	77626	12	22374	87211	18	12789	09585	6	90415	19
42	6 24	53 36	77643	12	22357	87238	18	12762	09595	7	90405	18
43	6 16	53 44	77660	12	22340	87264	19	12736	09604	7	90396	17
44	6 8	53 52	77677	13	22323	87290	19	12710	09614	7	90386	16
45	7 6 0	4 54 0	9.77694	13	10.22306	9.87317	20	10.12683	10.09623	7	9.90377	15
46	5 52	54 8	77711	13	22289	87343	20	12657	09632	7	90368	14
47	5 44	54 16	77728	13	22272	87369	21	12631	09642	7	90358	13
48	5 36	54 24	77744	14	22256	87396	21	12604	09651	7	90349	12
49	5 28	54 32	77761	14	22239	87422	22	12578	09661	8	90339	11
50	7 5 20	4 54 40	9.77778	14	10.22222	9.87448	22	10.12552	10.09670	8	9.90330	10
51	5 12	54 48	77795	15	22205	87475	22	12525	09680	8	90320	9
52	5 4	54 56	77812	15	22188	87501	23	12499	09689	8	90311	8
53	4 56	55 4	77829	15	22171	87527	23	12473	09699	8	90301	7
54	4 48	55 12	77846	15	22154	87554	24	12446	09708	8	90292	6
55	7 4 40	4 55 20	9.77862	16	10.22138	9.87580	24	10.12420	10.09718	9	9.90282	5
56	4 32	55 28	77879	16	22121	87606	25	12394	09727	9	90273	4
57	4 24	55 36	77896	16	22104	87633	25	12367	09737	9	90263	3
58	4 16	55 44	77913	16	22087	87659	26	12341	09746	9	90254	2
59	4 8	55 52	77930	17	22070	87685	26	12315	09756	9	90244	1
60	4 0	56 0	77946	17	22054	87711	26	12289	09765	9	90235	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
126°			A		A	B		B	C		C	53°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	4	6	9	11	13	15
	B	3	7	10	13	17	20	23
	C	1	2	4	5	6	7	8

Digitized by Google

TABLE XXVII.

S. G'

Log. Sines, Tangents, and Secants.

37° A A B B C C 142°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	7 4 0	4 56 0	9.77946	0	10.22054	9.87711	0	10.12289	10.09765	0	9.90235	60
1	3 52	56 8	77963	0	22037	87738	0	12262	09775	0	90225	59
2	3 44	56 16	77980	1	22020	87764	1	12236	09784	0	90216	58
3	3 36	56 24	77997	1	22003	87790	1	12210	09794	0	90206	57
4	3 28	56 32	78013	1	21987	87817	2	12183	09803	1	90197	56
5	7 3 20	4 56 40	9.78030	1	10.21970	9.87843	2	10.12157	10.09813	1	9.90187	55
6	3 12	56 48	78047	2	21953	87869	3	12131	09822	1	90178	54
7	3 4	56 56	78063	2	21937	87895	3	12105	09832	1	90168	53
8	2 56	57 4	78080	2	21920	87922	3	12078	09841	1	90159	52
9	2 48	57 12	78097	2	21903	87948	4	12052	09851	1	90149	51
10	7 2 40	4 57 20	9.78113	3	10.21887	9.87974	4	10.12026	10.09861	2	9.90139	50
11	2 32	57 28	78130	3	21870	88000	5	12000	09870	2	90130	49
12	2 24	57 36	78147	3	21853	88027	5	11973	09880	2	90120	48
13	2 16	57 44	78163	4	21837	88053	6	11947	09889	2	90111	47
14	2 8	57 52	78180	4	21820	88079	6	11921	09899	2	90101	46
15	7 2 0	4 58 0	9.78197	4	10.21803	9.88105	7	10.11895	10.09909	2	9.90091	45
16	1 52	58 8	78213	4	21787	88131	7	11869	09918	3	90082	44
17	1 44	58 16	78230	5	21770	88158	7	11842	09928	3	90072	43
18	1 36	58 24	78246	5	21754	88184	8	11816	09937	3	90063	42
19	1 28	58 32	78263	5	21737	88210	8	11790	09947	3	90053	41
20	7 1 20	4 58 40	9.78280	5	10.21720	9.88236	9	10.11764	10.09957	3	9.90043	40
21	1 12	58 48	78296	6	21704	88262	9	11738	09966	3	90034	39
22	1 4	58 56	78313	6	21687	88289	10	11711	09976	4	90024	38
23	0 56	59 4	78329	6	21671	88315	10	11685	09986	4	90014	37
24	0 48	59 12	78346	7	21654	88341	10	11659	09995	4	90005	36
25	7 0 40	4 59 20	9.78362	7	10.21638	9.88367	11	10.11633	10.10005	4	9.89995	35
26	0 32	59 28	78379	7	21621	88393	11	11607	10015	4	89985	34
27	0 24	59 36	78395	7	21605	88420	12	11580	10024	4	89976	33
28	0 16	59 44	78412	8	21588	88446	12	11554	10034	5	89966	32
29	0 8	59 52	78428	8	21572	88472	13	11528	10044	5	89956	31
30	7 0 0	5 0 0	9.78445	8	10.21555	9.88498	13	10.11502	10.10053	5	9.89947	30
31	6 59 52	0 8	78461	9	21539	88524	14	11476	10063	5	89937	29
32	59 44	0 16	78478	9	21522	88550	14	11450	10073	5	89927	28
33	59 36	0 24	78494	9	21506	88577	14	11423	10082	5	89918	27
34	59 28	0 32	78510	9	21490	88603	15	11397	10092	5	89908	26
35	6 59 20	5 0 40	9.78527	10	10.21473	9.88629	15	10.11371	10.10102	6	9.89898	25
36	59 12	0 48	78543	10	21457	88655	16	11345	10112	6	89888	24
37	59 4	0 56	78560	10	21440	88681	16	11319	10121	6	89879	23
38	58 56	1 4	78576	10	21424	88707	17	11293	10131	6	89869	22
39	58 48	1 12	78592	11	21408	88733	17	11267	10141	6	89859	21
40	6 58 40	5 1 20	9.78609	11	10.21391	9.88759	17	10.11241	10.10151	6	9.89849	20
41	58 32	1 28	78625	11	21375	88786	18	11214	10160	7	89840	19
42	58 24	1 36	78642	12	21358	88812	18	11188	10170	7	89830	18
43	58 16	1 44	78658	12	21342	88838	19	11162	10180	7	89820	17
44	58 8	1 52	78674	12	21326	88864	19	11136	10190	7	89810	16
45	6 58 0	5 2 0	9.78691	12	10.21309	9.88890	20	10.11110	10.10199	7	9.89801	15
46	57 52	2 8	78707	13	21293	88916	20	11084	10209	7	89791	14
47	57 44	2 16	78723	13	21277	88942	20	11058	10219	8	89781	13
48	57 36	2 24	78739	13	21261	88968	21	11032	10229	8	89771	12
49	57 28	2 32	78756	13	21244	88994	21	11006	10239	8	89761	11
50	6 57 20	5 2 40	9.78772	14	10.21228	9.89020	22	10.10980	10.10248	8	9.89752	10
51	57 12	2 48	78788	14	21212	89046	22	10954	10258	8	89742	9
52	57 4	2 56	78805	14	21195	89073	23	10927	10268	8	89732	8
53	56 56	3 4	78821	15	21179	89099	23	10901	10278	9	89722	7
54	56 48	3 12	78837	15	21163	89125	24	10875	10288	9	89712	6
55	6 56 40	5 3 20	9.78853	15	10.21147	9.89151	24	10.10849	10.10298	9	9.89702	5
56	56 32	3 28	78869	15	21131	89177	24	10823	10307	9	89693	4
57	56 24	3 36	78886	16	21114	89203	25	10797	10317	9	89683	3
58	56 16	3 44	78902	16	21098	89229	25	10771	10327	9	89673	2
59	56 8	3 52	78918	16	21082	89255	26	10745	10337	10	89663	1
60	56 0	4 0	78934	16	21066	89281	26	10719	10347	10	89653	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

127° A A B B C C 52°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols	A	2	4	6	8	10	12	14
	B	3	7	10	13	16	20	23
	C	1	2	4	5	6	7	8

Digitized by Google

TABLE XXVII.

5'. Log. Sines, Tangents, and Secants 6'.

38° A A B B C C 141°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	6 56 0	5 4 0	9.78934	0	10.21066	9.89281	0	10.10719	10.10347	0	9.89653	60
1	55 52	4 8	78950	0	21050	89307	0	10693	10357	0	89643	59
2	55 44	4 16	78967	1	21033	89333	1	10667	10367	0	89633	58
3	55 36	4 24	78983	1	21017	89359	1	10641	10376	1	89624	57
4	55 28	4 32	78999	1	21001	89385	2	10615	10386	1	89614	56
5	6 55 20	5 4 40	9.79015	1	10.20985	9.89411	2	10.10589	10.10396	1	9.89604	55
6	55 12	4 48	79031	2	20969	89437	3	10563	10406	1	89594	54
7	55 4	4 56	79047	2	20953	89463	3	10537	10416	1	89584	53
8	54 56	5 4	79063	2	20937	89489	3	10511	10426	1	89574	52
9	54 48	5 12	79079	2	20921	89515	4	10485	10436	2	89564	51
10	6 54 40	5 5 20	9.79095	3	10.20905	9.89541	4	10.10459	10.10446	2	9.89554	50
11	54 32	5 28	79111	3	20889	89567	5	10433	10456	2	89544	49
12	54 24	5 36	79128	3	20872	89593	5	10407	10466	2	89534	48
13	54 16	5 44	79144	3	20856	89619	6	10381	10476	2	89524	47
14	54 8	5 52	79160	4	20840	89645	6	10355	10486	2	89514	46
15	6 54 0	5 6 0	9.79176	4	10.20824	9.89671	6	10.10329	10.10496	3	9.89504	45
16	53 52	6 8	79192	4	20808	89697	7	10303	10505	3	89495	44
17	53 44	6 16	79208	5	20792	89723	7	10277	10515	3	89485	43
18	53 36	6 24	79224	5	20776	89749	8	10251	10525	3	89475	42
19	53 28	6 32	79240	5	20760	89775	8	10225	10535	3	89465	41
20	6 53 20	5 6 40	9.79256	5	10.20744	9.89801	9	10.10199	10.10545	3	9.89455	40
21	53 12	6 48	79272	6	20728	89827	9	10173	10555	4	89445	39
22	53 4	6 56	79288	6	20712	89853	10	10147	10565	4	89435	38
23	52 56	7 4	79304	6	20696	89879	10	10121	10575	4	89425	37
24	52 48	7 12	79319	6	20681	89905	10	10095	10585	4	89415	36
25	6 52 40	5 7 20	9.79335	7	10.20665	9.89931	11	10.10069	10.10595	4	9.89405	35
26	52 32	7 28	79351	7	20649	89957	11	10043	10605	4	89395	34
27	52 24	7 36	79367	7	20633	89983	12	10017	10615	5	89385	33
28	52 16	7 44	79383	7	20617	90009	12	09991	10625	5	89375	32
29	52 8	7 52	79399	8	20601	90035	13	09965	10636	5	89364	31
30	6 52 0	5 8 0	9.79415	8	10.20585	9.90061	13	10.09939	10.10646	5	9.89354	30
31	51 52	8 8	79431	8	20569	90086	13	09914	10656	5	89344	29
32	51 44	8 16	79447	8	20553	90112	14	09888	10666	5	89334	28
33	51 36	8 24	79463	9	20537	90138	14	09862	10676	6	89324	27
34	51 28	8 32	79478	9	20522	90164	15	09836	10686	6	89314	26
35	6 51 20	5 8 40	9.79494	9	10.20506	9.90190	15	10.09810	10.10696	6	9.89304	25
36	51 12	8 48	79510	10	20490	90216	16	09784	10706	6	89294	24
37	51 4	8 56	79526	10	20474	90242	16	09758	10716	6	89284	23
38	50 56	9 4	79542	10	20458	90268	16	09732	10726	6	89274	22
39	50 48	9 12	79558	10	20442	90294	17	09706	10736	7	89264	21
40	6 50 40	5 9 20	9.79573	11	10.20427	9.90320	17	10.09680	10.10746	7	9.89254	20
41	50 32	9 28	79589	11	20411	90346	18	09654	10756	7	89244	19
42	50 24	9 36	79605	11	20395	90371	18	09629	10767	7	89233	18
43	50 16	9 44	79621	11	20379	90397	19	09603	10777	7	89223	17
44	50 8	9 52	79636	12	20364	90423	19	09577	10787	7	89213	16
45	6 50 0	5 10 0	9.79652	12	10.20348	9.90449	19	10.09551	10.10797	8	9.89203	15
46	49 52	10 8	79668	12	20332	90475	20	09525	10807	8	89193	14
47	49 44	10 16	79684	12	20316	90501	20	09499	10817	8	89183	13
48	49 36	10 24	79699	13	20301	90527	21	09473	10827	8	89173	12
49	49 28	10 32	79715	13	20285	90553	21	09447	10838	8	89162	11
50	6 49 20	5 10 40	9.79731	13	10.20269	9.90578	22	10.09422	10.10848	8	9.89152	10
51	49 12	10 48	79746	14	20254	90604	22	09396	10858	9	89142	9
52	49 4	10 56	79762	14	20238	90630	22	09370	10868	9	89132	8
53	48 56	11 4	79778	14	20222	90656	23	09344	10878	9	89122	7
54	48 48	11 12	79793	14	20207	90682	23	09318	10888	9	89112	6
55	6 48 40	5 11 20	9.79809	15	10.20191	9.90708	24	10.09292	10.10899	9	9.89101	5
56	48 32	11 28	79825	15	20175	90734	24	09266	10909	9	89091	4
57	48 24	11 36	79840	15	20160	90759	25	09241	10919	10	89081	3
58	48 16	11 44	79856	15	20144	90785	25	09215	10929	10	89071	2
59	48 8	11 52	79872	16	20128	90811	26	09189	10940	10	89060	1
60	48 0	12 0	79887	16	20113	90837	26	09163	10950	10	89050	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

128° A A B B C C 51°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop parts of cols.	A	2	4	6	8	10	12	14
	B	3	6	10	13	16	19	23
	C	1	3	4	5	6	8	9

Digitized by Google

TABLE XXVII.

S'. G'.

Log. Sines, Tangents, and Secants.

39° A A B B C C 140°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	6 48 0	5 12 0	9.79887	0	10.20113	9.90837	0	10.09163	10.10950	0	9.89050	60
1	47 52	12 8	79903	0	20097	90863	0	09137	10960	0	89040	59
2	47 44	12 16	79918	1	20082	90889	1	09111	10970	0	89030	58
3	47 36	12 24	79934	1	20066	90914	1	09086	10980	1	89020	57
4	47 28	12 32	79950	1	20050	90940	2	09060	10991	1	89009	56
5	6 47 20	5 12 40	9.79965	1	10.20035	9.90966	2	10.09034	10.11001	1	9.88999	55
6	47 12	12 48	79981	2	20019	90992	3	09008	11011	1	88989	54
7	47 4	12 56	79996	2	20004	91018	3	08982	11022	1	88978	53
8	46 56	13 4	80012	2	19988	91043	3	08957	11032	1	88968	52
9	46 48	13 12	80027	2	19973	91069	4	08931	11042	2	88958	51
10	6 46 40	5 13 20	9.80043	3	10.19957	9.91095	4	10.08905	10.11052	2	9.88948	50
11	46 32	13 28	80058	3	19942	91121	5	08879	11063	2	88937	49
12	46 24	13 36	80074	3	19926	91147	5	08853	11073	2	88927	48
13	46 16	13 44	80089	3	19911	91172	6	08828	11083	2	88917	47
14	46 8	13 52	80105	4	19895	91198	6	08802	11094	2	88906	46
15	6 46 0	5 14 0	9.80120	4	10.19880	9.91224	6	10.08776	10.11104	3	9.88896	45
16	45 52	14 8	80136	4	19864	91250	7	08750	11114	3	88886	44
17	45 44	14 16	80151	4	19849	91276	7	08724	11125	3	88875	43
18	45 36	14 24	80166	5	19834	91301	8	08699	11135	3	88865	42
19	45 28	14 32	80182	5	19818	91327	8	08673	11145	3	88855	41
20	6 45 20	5 14 40	9.80197	5	10.19803	9.91353	9	10.08647	10.11156	3	9.88844	40
21	45 12	14 48	80213	5	19787	91379	9	08621	11166	4	88834	39
22	45 4	14 56	80228	6	19772	91404	9	08596	11176	4	88824	38
23	44 56	15 4	80244	6	19756	91430	10	08570	11187	4	88813	37
24	44 48	15 12	80259	6	19741	91456	10	08544	11197	4	88803	36
25	6 44 40	5 15 20	9.80274	6	10.19726	9.91482	11	10.08518	10.11207	4	9.88793	35
26	44 32	15 28	80290	7	19710	91507	11	08493	11218	5	88782	34
27	44 24	15 36	80305	7	19695	91533	12	08467	11228	5	88772	33
28	44 16	15 44	80320	7	19680	91559	12	08441	11239	5	88761	32
29	44 8	15 52	80336	7	19664	91585	12	08415	11249	5	88751	31
30	6 44 0	5 16 0	9.80351	8	10.19649	9.91610	13	10.08390	10.11259	5	9.88741	30
31	43 52	16 8	80366	8	19634	91636	13	08364	11270	5	88730	29
32	43 44	16 16	80382	8	19618	91662	14	08338	11280	6	88720	28
33	43 36	16 24	80397	8	19603	91688	14	08312	11291	6	88709	27
34	43 28	16 32	80412	9	19588	91713	15	08287	11301	6	88699	26
35	6 43 20	5 16 40	9.80428	9	10.19572	9.91739	15	10.08261	10.11312	6	9.88688	25
36	43 12	16 48	80443	9	19557	91765	15	08235	11322	6	88678	24
37	43 4	16 56	80458	9	19542	91791	16	08209	11332	6	88668	23
38	42 56	17 4	80473	10	19527	91816	16	08184	11343	7	88657	22
39	42 48	17 12	80489	10	19511	91842	17	08158	11353	7	88647	21
40	6 42 40	5 17 20	9.80504	10	10.19496	9.91868	17	10.08132	10.11364	7	9.88636	20
41	42 32	17 28	80519	10	19481	91893	18	08107	11374	7	88626	19
42	42 24	17 36	80534	11	19466	91919	18	08081	11385	7	88615	18
43	42 16	17 44	80550	11	19450	91945	18	08055	11395	7	88605	17
44	42 8	17 52	80565	11	19435	91971	19	08029	11406	8	88594	16
45	6 42 0	5 18 0	9.80580	12	10.19420	9.91996	19	10.08004	10.11416	8	9.88584	15
46	41 52	18 8	80595	12	19405	92022	20	07978	11427	8	88573	14
47	41 44	18 16	80610	12	19390	92048	20	07952	11437	8	88563	13
48	41 36	18 24	80625	12	19375	92073	21	07927	11448	8	88552	12
49	41 28	18 32	80641	13	19359	92099	21	07901	11458	9	88542	11
50	6 41 20	5 18 40	9.80656	13	10.19344	9.92125	21	10.07875	10.11469	9	9.88531	10
51	41 12	18 48	80671	13	19329	92150	22	07850	11479	9	88521	9
52	41 4	18 56	80686	13	19314	92176	22	07824	11490	9	88510	8
53	40 56	19 4	80701	14	19299	92202	23	07798	11501	9	88499	7
54	40 48	19 12	80716	14	19284	92227	23	07773	11511	9	88489	6
55	6 40 40	5 19 20	9.80731	14	10.19269	9.92253	24	10.07747	10.11522	10	9.88478	5
56	40 32	19 28	80746	14	19254	92279	24	07721	11532	10	88468	4
57	40 24	19 36	80762	15	19238	92304	24	07696	11543	10	88457	3
58	40 16	19 44	80777	15	19223	92330	25	07670	11553	10	88447	2
59	40 8	19 52	80792	15	19208	92356	25	07644	11564	10	88436	1
60	40 0	20 0	80807	15	19193	92381	26	07619	11575	10	88425	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

129° A A B B C C 50°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	4	6	8	10	12	13
	B	3	6	10	13	16	19	23
	C	1	3	4	5	7	8	9

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

S'. 40° | A | A | B | B | C | C 139° | G.

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine	M
0	6 40 0	5 20 0	9.80807	0	10.19193	9.92381	0	10.07619	10.11575	0	9.88425	60
1	39 52	20 8	80822	0	19178	92407	0	07593	11585	0	88415	59
2	39 44	20 16	80837	0	19163	92433	1	07567	11596	0	88404	58
3	39 36	20 24	80852	1	19148	92458	1	07542	11606	1	88394	57
4	39 28	20 32	80867	1	19133	92484	2	07516	11617	1	88383	56
5	6 39 20	5 20 40	9.80882	1	10.19118	9.92510	2	10.07490	10.11628	1	9.88372	55
6	39 12	20 48	80897	1	19103	92535	3	07465	11638	1	88362	54
7	39 4	20 56	80912	2	19088	92561	3	07439	11649	1	88351	53
8	38 56	21 4	80927	2	19073	92587	3	07413	11660	1	88340	52
9	38 48	21 12	80942	2	19058	92612	4	07388	11670	2	88330	51
10	6 38 40	5 21 20	9.80957	2	10.19043	9.92638	4	10.07362	10.11681	2	9.88319	50
11	38 32	21 28	80972	3	19028	92663	5	07337	11692	2	88308	49
12	38 24	21 36	80987	3	19013	92689	5	07311	11702	2	88298	48
13	38 16	21 44	81002	3	18998	92715	6	07285	11713	2	88287	47
14	38 8	21 52	81017	3	18983	92740	6	07260	11724	3	88276	46
15	6 38 0	5 22 0	9.81032	4	10.18968	9.92766	6	10.07234	10.11734	3	9.88266	45
16	37 52	22 8	81047	4	18953	92792	7	07208	11745	3	88255	44
17	37 44	22 16	81061	4	18939	92817	7	07183	11756	3	88244	43
18	37 36	22 24	81076	4	18924	92843	8	07157	11766	3	88234	42
19	37 28	22 32	81091	5	18909	92868	8	07132	11777	3	88223	41
20	6 37 20	5 22 40	9.81106	5	10.18894	9.92894	9	10.07106	10.11788	4	9.88212	40
21	37 12	22 48	81121	5	18879	92920	9	07080	11799	4	88201	39
22	37 4	22 56	81136	5	18864	92945	9	07055	11809	4	88191	38
23	36 56	23 4	81151	6	18849	92971	10	07029	11820	4	88180	37
24	36 48	23 12	81166	6	18834	92996	10	07004	11831	4	88169	36
25	6 36 40	5 23 20	9.81180	6	10.18820	9.93022	11	10.06978	10.11842	4	9.88158	35
26	36 32	23 28	81195	6	18805	93048	11	06952	11852	5	88148	34
27	36 24	23 36	81210	7	18790	93073	12	06927	11863	5	88137	33
28	36 16	23 44	81225	7	18775	93099	12	06901	11874	5	88126	32
29	36 8	23 52	81240	7	18760	93124	12	06876	11885	5	88115	31
30	6 36 0	5 24 0	9.81254	7	10.18746	9.93150	13	10.06850	10.11895	5	9.88105	30
31	35 52	24 8	81269	8	18731	93175	13	06825	11906	6	88094	29
32	35 44	24 16	81284	8	18716	93201	14	06799	11917	6	88083	28
33	35 36	24 24	81299	8	18701	93227	14	06773	11928	6	88072	27
34	35 28	24 32	81314	8	18686	93252	14	06748	11939	6	88061	26
35	6 35 20	5 24 40	9.81328	9	10.18672	9.93278	15	10.06722	10.11949	6	9.88051	25
36	35 12	24 48	81343	9	18657	93303	15	06697	11960	6	88040	24
37	35 4	24 56	81358	9	18642	93329	16	06671	11971	7	88029	23
38	34 56	25 4	81372	9	18628	93354	16	06646	11982	7	88018	22
39	34 48	25 12	81387	10	18613	93380	17	06620	11993	7	88007	21
40	6 34 40	5 25 20	9.81402	10	10.18598	9.93406	17	10.06594	10.12004	7	9.87996	20
41	34 32	25 28	81417	10	18583	93431	17	06569	12015	7	87985	19
42	34 24	25 36	81431	10	18569	93457	18	06543	12025	8	87975	18
43	34 16	25 44	81446	11	18554	93482	18	06518	12036	8	87964	17
44	34 8	25 52	81461	11	18539	93508	19	06492	12047	8	87953	16
45	6 34 0	5 26 0	9.81475	11	10.18525	9.93533	19	10.06467	10.12058	8	9.87942	15
46	33 52	26 8	81490	11	18510	93559	20	06441	12069	8	87931	14
47	33 44	26 16	81505	12	18495	93584	20	06416	12080	8	87920	13
48	33 36	26 24	81519	12	18481	93610	20	06390	12091	9	87909	12
49	33 28	26 32	81534	12	18466	93636	21	06364	12102	9	87898	11
50	6 33 20	5 26 40	9.81549	12	10.18451	9.93661	21	10.06339	10.12113	9	9.87887	10
51	33 12	26 48	81563	13	18437	93687	22	06313	12123	9	87877	9
52	33 4	26 56	81578	13	18422	93712	22	06288	12134	9	87866	8
53	32 56	27 4	81592	13	18408	93738	23	06262	12145	10	87855	7
54	32 48	27 12	81607	13	18393	93763	23	06237	12156	10	87844	6
55	6 32 40	5 27 20	9.81622	14	10.18378	9.93789	23	10.06211	10.12167	10	9.87833	5
56	32 32	27 28	81636	14	18364	93814	24	06186	12178	10	87822	4
57	32 24	27 36	81651	14	18349	93840	24	06160	12189	10	87811	3
58	32 16	27 44	81665	14	18335	93865	25	06135	12200	10	87800	2
59	32 8	27 52	81680	15	18320	93891	25	06109	12211	11	87789	1
60	32 0	28 0	81694	15	18306	93916	26	06084	12222	11	87778	0
M	Hour P.M.	Hour A.M.	Cosine	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

130° | A | A | B | B | C | C 49°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	4	6	7	9	11	13
	B	3	6	10	13	16	19	22
	C	1	3	4	5	7	8	9

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

41°			A		A	B		B	C		C	138°
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	6 32 0	5 28 0	9.81694	0	10.18306	9.93916	0	10.06084	10.12222	0	9.87778	60
1	31 52	28 8	81709	0	18291	93942	0	06058	12233	0	87767	59
2	31 44	28 16	81723	0	18277	93967	1	06033	12244	0	87756	58
3	31 36	28 24	81738	1	18262	93993	1	06007	12255	1	87745	57
4	31 28	28 32	81752	1	18248	94018	2	05982	12266	1	87734	56
5	6 31 20	5 28 40	9.81767	1	10.18233	9.94044	2	10.05956	10.12277	1	9.87723	55
6	31 12	28 48	81781	1	18219	94069	3	05931	12288	1	87712	54
7	31 4	28 56	81796	2	18204	94095	3	05905	12299	1	87701	53
8	30 56	29 4	81810	2	18190	94120	3	05880	12310	1	87690	52
9	30 48	29 12	81825	2	18175	94146	4	05854	12321	2	87679	51
10	6 30 40	5 29 20	9.81839	2	10.18161	9.94171	4	10.05829	10.12332	2	9.87668	50
11	30 32	29 28	81854	3	18146	94197	5	05803	12343	2	87657	49
12	30 24	29 36	81868	3	18132	94222	5	05778	12354	2	87646	48
13	30 16	29 44	81882	3	18118	94248	6	05752	12365	2	87635	47
14	30 8	29 52	81897	3	18103	94273	6	05727	12376	3	87624	46
15	6 30 0	5 30 0	9.81911	4	10.18089	9.94299	6	10.05701	10.12387	3	9.87613	45
16	29 52	30 8	81926	4	18074	94324	7	05676	12399	3	87601	44
17	29 44	30 16	81940	4	18060	94350	7	05650	12410	3	87590	43
18	29 36	30 24	81955	4	18045	94375	8	05625	12421	3	87579	42
19	29 28	30 32	81969	5	18031	94401	8	05599	12432	4	87568	41
20	6 29 20	5 30 40	9.81983	5	10.18017	9.94426	8	10.05574	10.12443	4	9.87557	40
21	29 12	30 48	81998	5	18002	94452	9	05548	12454	4	87546	39
22	29 4	30 56	82012	5	17988	94477	9	05523	12465	4	87535	38
23	28 56	31 4	82026	5	17974	94503	10	05497	12476	4	87524	37
24	28 48	31 12	82041	6	17959	94528	10	05472	12487	4	87513	36
25	6 28 40	5 31 20	9.82055	6	10.17945	9.94554	11	10.05446	10.12499	5	9.87501	35
26	28 32	31 28	82069	6	17931	94579	11	05421	12510	5	87490	34
27	28 24	31 36	82084	6	17916	94604	11	05396	12521	5	87479	33
28	28 16	31 44	82098	7	17902	94630	12	05370	12532	5	87468	32
29	28 8	31 52	82112	7	17888	94655	12	05345	12543	5	87457	31
30	6 28 0	5 32 0	9.82126	7	10.17874	9.94681	13	10.05319	10.12554	6	9.87446	30
31	27 52	32 8	82141	7	17859	94706	13	05294	12566	6	87434	29
32	27 44	32 16	82155	8	17845	94732	14	05268	12577	6	87423	28
33	27 36	32 24	82169	8	17831	94757	14	05243	12588	6	87412	27
34	27 28	32 32	82184	8	17816	94783	14	05217	12599	6	87401	26
35	6 27 20	5 32 40	9.82198	8	10.17802	9.94808	15	10.05192	10.12610	7	9.87390	25
36	27 12	32 48	82212	9	17788	94834	15	05166	12622	7	87378	24
37	27 4	32 56	82226	9	17774	94859	16	05141	12633	7	87367	23
38	26 56	33 4	82240	9	17760	94884	16	05116	12644	7	87356	22
39	26 48	33 12	82255	9	17745	94910	17	05090	12655	7	87345	21
40	6 26 40	5 33 20	9.82269	10	10.17731	9.94935	17	10.05065	10.12666	7	9.87334	20
41	26 32	33 28	82283	10	17717	94961	17	05039	12678	8	87322	19
42	26 24	33 36	82297	10	17703	94986	18	05014	12689	8	87311	18
43	26 16	33 44	82311	10	17689	95012	18	04988	12700	8	87300	17
44	26 8	33 52	82326	10	17674	95037	19	04963	12712	8	87288	16
45	6 26 0	5 34 0	9.82340	11	10.17660	9.95062	19	10.04938	10.12723	8	9.87277	15
46	25 52	34 8	82354	11	17646	95088	20	04912	12734	9	87266	14
47	25 44	34 16	82368	11	17632	95113	20	04887	12745	9	87255	13
48	25 36	34 24	82382	11	17618	95139	20	04861	12757	9	87243	12
49	25 28	34 32	82396	12	17604	95164	21	04836	12768	9	87232	11
50	6 25 20	5 34 40	9.82410	12	10.17590	9.95190	21	10.04810	10.12779	9	9.87221	10
51	25 12	34 48	82424	12	17576	95215	22	04785	12791	10	87209	9
52	25 4	34 56	82439	12	17561	95240	22	04760	12802	10	87198	8
53	24 56	35 4	82453	13	17547	95266	22	04734	12813	10	87187	7
54	24 48	35 12	82467	13	17533	95291	23	04709	12825	10	87175	6
55	6 24 40	5 35 20	9.82481	13	10.17519	9.95317	23	10.04683	10.12836	10	9.87164	5
56	24 32	35 28	82495	13	17505	95342	24	04658	12847	10	87153	4
57	24 24	35 36	82509	14	17491	95368	24	04632	12859	11	87141	3
58	24 16	35 44	82523	14	17477	95393	25	04607	12870	11	87130	2
59	24 8	35 52	82537	14	17463	95418	25	04582	12881	11	87119	1
60	24 0	36 0	82551	14	17449	95444	25	04556	12893	11	87107	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
131°			A		A	B		B	C		C	48°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	4	5	7	9	11	12
	B	3	6	10	13	16	19	22
	C	1	3	4	6	7	8	10

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

42°			A		A	B		B	C		C	137°
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	6 24 0	5 36 0	9.82551	0	10.17449	9.95444	0	10.04556	10.12893	0	9.87107	60
1	23 52	36 8	82565	0	17435	95469	0	04531	12904	0	87096	59
2	23 44	36 16	82579	0	17421	95495	1	04505	12915	0	87085	58
3	23 36	36 24	82593	1	17407	95520	1	04480	12927	1	87073	57
4	23 28	36 32	82607	1	17393	95545	2	04455	12938	1	87062	56
5	6 23 20	5 36 40	9.82621	1	10.17379	9.95571	2	10.04429	10.12950	1	9.87050	55
6	23 12	36 48	82635	1	17365	95596	3	04404	12961	1	87039	54
7	23 4	36 56	82649	2	17351	95622	3	04378	12972	1	87028	53
8	22 56	37 4	82663	2	17337	95647	3	04353	12984	2	87016	52
9	22 48	37 12	82677	2	17323	95672	4	04328	12995	2	87005	51
10	6 22 40	5 37 20	9.82691	2	10.17309	9.95698	4	10.04302	10.13007	2	9.86993	50
11	22 32	37 28	82705	3	17295	95723	5	04277	13018	2	86982	49
12	22 24	37 36	82719	3	17281	95748	5	04252	13030	2	86970	48
13	22 16	37 44	82733	3	17267	95774	5	04226	13041	3	86959	47
14	22 8	37 52	82747	3	17253	95799	6	04201	13053	3	86947	46
15	6 22 0	5 38 0	9.82761	3	10.17239	9.95825	6	10.04175	10.13064	3	9.86936	45
16	21 52	38 8	82775	4	17225	95850	7	04150	13076	3	86924	44
17	21 44	38 16	82788	4	17212	95875	7	04125	13087	3	86913	43
18	21 36	38 24	82802	4	17198	95901	8	04099	13098	3	86902	42
19	21 28	38 32	82816	4	17184	95926	8	04074	13110	4	86890	41
20	6 21 20	5 38 40	9.82830	5	10.17170	9.95952	8	10.04048	10.13121	4	9.86879	40
21	21 12	38 48	82844	5	17156	95977	9	04023	13133	4	86867	39
22	21 4	38 56	82858	5	17142	96002	9	03998	13145	4	86855	38
23	20 56	39 4	82872	5	17128	96028	10	03972	13156	4	86844	37
24	20 48	39 12	82885	6	17115	96053	10	03947	13168	5	86832	36
25	6 20 40	5 39 20	9.82899	6	10.17101	9.96078	11	10.03922	10.13179	5	9.86821	35
26	20 32	39 28	82913	6	17087	96104	11	03896	13191	5	86809	34
27	20 24	39 36	82927	6	17073	96129	11	03871	13202	5	86798	33
28	20 16	39 44	82941	6	17059	96155	12	03845	13214	5	86786	32
29	20 8	39 52	82955	7	17045	96180	12	03820	13225	6	86775	31
30	6 20 0	5 40 0	9.82968	7	10.17032	9.96205	13	10.03795	10.13237	6	9.86763	30
31	19 52	40 8	82982	7	17018	96231	13	03769	13248	6	86752	29
32	19 44	40 16	82996	7	17004	96256	14	03744	13260	6	86740	28
33	19 36	40 24	83010	8	16990	96281	14	03719	13272	6	86728	27
34	19 28	40 32	83023	8	16977	96307	14	03693	13283	7	86717	26
35	6 19 20	5 40 40	9.83037	8	10.16963	9.96332	15	10.03668	10.13295	7	9.86705	25
36	19 12	40 48	83051	8	16949	96357	15	03643	13306	7	86694	24
37	19 4	40 56	83065	8	16935	96383	16	03617	13318	7	86682	23
38	18 56	41 4	83078	9	16922	96408	16	03592	13330	7	86670	22
39	18 48	41 12	83092	9	16908	96433	16	03567	13341	8	86659	21
40	6 18 40	5 41 20	9.83106	9	10.16894	9.96459	17	10.03541	10.13353	8	9.86647	20
41	18 32	41 28	83120	9	16880	96484	17	03516	13365	8	86635	19
42	18 24	41 36	83133	10	16867	96510	18	03490	13376	8	86624	18
43	18 16	41 44	83147	10	16853	96535	18	03465	13388	8	86612	17
44	18 8	41 52	83161	10	16839	96560	19	03440	13400	8	86600	16
45	6 18 0	5 42 0	9.83174	10	10.16826	9.96586	19	10.03414	10.13411	9	9.86589	15
46	17 52	42 8	83188	11	16812	96611	19	03389	13423	9	86577	14
47	17 44	42 16	83202	11	16798	96636	20	03364	13435	9	86565	13
48	17 36	42 24	83215	11	16785	96662	20	03338	13446	9	86554	12
49	17 28	42 32	83229	11	16771	96687	21	03313	13458	9	86542	11
50	6 17 20	5 42 40	9.83242	11	10.16758	9.96712	21	10.03288	10.13470	10	9.86530	10
51	17 12	42 48	83256	12	16744	96738	22	03262	13482	10	86518	9
52	17 4	42 56	83270	12	16730	96763	22	03237	13493	10	86507	8
53	16 56	43 4	83283	12	16717	96788	22	03212	13505	10	86495	7
54	16 48	43 12	83297	12	16703	96814	23	03186	13517	10	86483	6
55	6 16 40	5 43 20	9.83310	13	10.16690	9.96839	23	10.03161	10.13528	11	9.86472	5
56	16 32	43 28	83324	13	16676	96864	24	03136	13540	11	86460	4
57	16 24	43 36	83338	13	16662	96890	24	03110	13552	11	86448	3
58	16 16	43 44	83351	13	16649	96915	25	03085	13564	11	86436	2
59	16 8	43 52	83365	14	16635	96940	25	03060	13575	11	86425	1
60	16 0	44 0	83378	14	16622	96966	25	03034	13587	12	86413	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
132°			A		A	B		B	C		C	47

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	3	5	7	9	10	12
	B	3	6	10	13	16	19	22

TABLE XXVII.

8'. **Log. Sines, Tangents, and Secants.** G'.

43° | A | A | B | B | C | C 136°

M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant	Diff.	Cosine.	M
0	6 16 0	5 44 0	9.83378	0	10.16622	9.96966	0	10.03034	10.13587	0	9.86413	60
1	15 52	44 8	83392	0	16608	96991	0	03009	13599	0	86401	59
2	15 44	44 16	83405	0	16595	97016	1	02984	13611	0	86389	58
3	15 36	44 24	83419	1	16581	97042	1	02958	13623	1	86377	57
4	15 28	44 32	83432	1	16568	97067	2	02933	13634	1	86366	56
5	6 15 20	5 44 40	9.83446	1	10.16554	9.97092	2	10.02908	10.13646	1	9.86354	55
6	15 12	44 48	83459	1	16541	97118	3	02882	13658	1	86342	54
7	15 4	44 56	83473	2	16527	97143	3	02857	13670	1	86330	53
8	14 56	45 4	83486	2	16514	97168	3	02832	13682	2	86318	52
9	14 48	45 12	83500	2	16500	97193	4	02807	13694	2	86306	51
10	6 14 40	5 45 20	9.83513	2	10.16487	9.97219	4	10.02781	10.13705	2	9.86295	50
11	14 32	45 28	83527	2	16473	97244	5	02756	13717	2	86283	49
12	14 24	45 36	83540	3	16460	97269	5	02731	13729	2	86271	48
13	14 16	45 44	83554	3	16446	97295	5	02705	13741	3	86259	47
14	14 8	45 52	83567	3	16433	97320	6	02680	13753	3	86247	46
15	6 14 0	5 46 0	9.83581	3	10.16419	9.97345	6	10.02655	10.13765	3	9.86235	45
16	13 52	46 8	83594	4	16406	97371	7	02629	13777	3	86223	44
17	13 44	46 16	83608	4	16392	97396	7	02604	13789	3	86211	43
18	13 36	46 24	83621	4	16379	97421	8	02579	13800	4	86200	42
19	13 28	46 32	83634	4	16366	97447	8	02553	13812	4	86188	41
20	6 13 20	5 46 40	9.83648	4	10.16352	9.97472	8	10.02528	10.13824	4	9.86176	40
21	13 12	46 48	83661	5	16339	97497	9	02503	13836	4	86164	39
22	13 4	46 56	83674	5	16326	97523	9	02477	13848	4	86152	38
23	12 56	47 4	83688	5	16312	97548	10	02452	13860	5	86140	37
24	12 48	47 12	83701	5	16299	97573	10	02427	13872	5	86128	36
25	6 12 40	5 47 20	9.83715	6	10.16285	9.97598	11	10.02402	10.13884	5	9.86116	35
26	12 32	47 28	83728	6	16272	97624	11	02376	13896	5	86104	34
27	12 24	47 36	83741	6	16259	97649	11	02351	13908	5	86092	33
28	12 16	47 44	83755	6	16245	97674	12	02326	13920	6	86080	32
29	12 8	47 52	83768	6	16232	97700	12	02300	13932	6	86068	31
30	6 12 0	5 48 0	9.83781	7	10.16219	9.97725	13	10.02275	10.13944	6	9.86056	30
31	11 52	48 8	83795	7	16205	97750	13	02250	13956	6	86044	29
32	11 44	48 16	83808	7	16192	97776	13	02224	13968	6	86032	28
33	11 36	48 24	83821	7	16179	97801	14	02199	13980	7	86020	27
34	11 28	48 32	83834	8	16166	97826	14	02174	13992	7	86008	26
35	6 11 20	5 48 40	9.83848	8	10.16152	9.97851	15	10.02149	10.14004	7	9.85996	25
36	11 12	48 48	83861	8	16139	97877	15	02123	14016	7	85984	24
37	11 4	48 56	83874	8	16126	97902	16	02098	14028	7	85972	23
38	10 56	49 4	83887	8	16113	97927	16	02073	14040	8	85960	22
39	10 48	49 12	83901	9	16099	97953	16	02047	14052	8	85948	21
40	6 10 40	5 49 20	9.83914	9	10.16086	9.97978	17	10.02022	10.14064	8	9.85936	20
41	10 32	49 28	83927	9	16073	98003	17	01997	14076	8	85924	19
42	10 24	49 36	83940	9	16060	98029	18	01971	14088	8	85912	18
43	10 16	49 44	83954	10	16046	98054	18	01946	14100	9	85900	17
44	10 8	49 52	83967	10	16033	98079	19	01921	14112	9	85888	16
45	6 10 0	5 50 0	9.83980	10	10.16020	9.98104	19	10.01896	10.14124	9	9.85876	15
46	9 52	50 8	83993	10	16007	98130	19	01870	14136	9	85864	14
47	9 44	50 16	84006	10	15994	98155	20	01845	14149	9	85851	13
48	9 36	50 24	84020	11	15980	98180	20	01820	14161	10	85839	12
49	9 28	50 32	84033	11	15967	98206	21	01794	14173	10	85827	11
50	6 9 20	5 50 40	9.84046	11	10.15954	9.98231	21	10.01769	10.14185	10	9.85815	10
51	9 12	50 48	84059	11	15941	98256	22	01744	14197	10	85803	9
52	9 4	50 56	84072	12	15928	98281	22	01719	14209	10	85791	8
53	8 56	51 4	84085	12	15915	98307	22	01693	14221	11	85779	7
54	8 48	51 12	84098	12	15902	98332	23	01668	14234	11	85766	6
55	6 8 40	5 51 20	9.84112	12	10.15888	9.98357	23	10.01643	10.14246	11	9.85754	5
56	8 32	51 28	84125	12	15875	98383	24	01617	14258	11	85742	4
57	8 24	51 36	84138	13	15862	98408	24	01592	14270	11	85730	3
58	8 16	51 44	84151	13	15849	98433	24	01567	14282	12	85718	2
59	8 8	51 52	84164	13	15836	98458	25	01542	14294	12	85706	1
60	8 0	52 0	84177	13	15823	98484	25	01516	14307	12	85693	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M

133° | A | A | B | B | C | C 46°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	3	5	7	8	10	12
	B	3	6	9	13	16	19	22
	C	2	3	5	6	8	9	11

Digitized by Google

TABLE XXVII.

Log. Sines, Tangents, and Secants.

G'.

14°			A		A	B		B	C		C	135°
M	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M
0	6 8 0	5 52 0	9.84177	0	10.15823	9.98484	0	10.01516	10.14307	0	9.85693	60
1	7 52	52 8	84190	0	15810	98509	0	01491	14319	0	85681	59
2	7 44	52 16	84203	0	15797	98534	1	01466	14331	0	85669	58
3	7 36	52 24	84216	1	15784	98560	1	01440	14343	1	85657	57
4	7 28	52 32	84229	1	15771	98585	2	01415	14355	1	85645	56
5	6 7 20	5 52 40	9.84242	1	10.15758	9.98610	2	10.01390	10.14368	1	9.85632	55
6	7 12	52 48	84255	1	15745	98635	3	01365	14380	1	85620	54
7	7 4	52 56	84269	2	15731	98661	3	01339	14392	1	85608	53
8	6 56	53 4	84282	2	15718	98686	3	01314	14404	2	85596	52
9	6 48	53 12	84295	2	15705	98711	4	01289	14417	2	85583	51
10	6 6 40	5 53 20	9.84308	2	10.15692	9.98737	4	10.01263	10.14429	2	9.85571	50
11	6 32	53 28	84321	2	15679	98762	5	01238	14441	2	85559	49
12	6 24	53 36	84334	3	15666	98787	5	01213	14453	2	85547	48
13	6 16	53 44	84347	3	15653	98812	5	01188	14466	3	85534	47
14	6 8	53 52	84360	3	15640	98838	6	01162	14478	3	85522	46
15	6 6 0	5 54 0	9.84373	3	10.15627	9.98863	6	10.01137	10.14490	3	9.85510	45
16	5 52	54 8	84385	3	15615	98888	7	01112	14503	3	85497	44
17	5 44	54 16	84398	4	15602	98913	7	01087	14515	4	85485	43
18	5 36	54 24	84411	4	15589	98939	8	01061	14527	4	85473	42
19	5 28	54 32	84424	4	15576	98964	8	01036	14540	4	85460	41
20	6 5 20	5 54 40	9.84437	4	10.15563	9.98989	8	10.01011	10.14552	4	9.85448	40
21	5 12	54 48	84450	5	15550	99015	9	00985	14564	4	85436	39
22	5 4	54 56	84463	5	15537	99040	9	00960	14577	5	85423	38
23	4 56	55 4	84476	5	15524	99065	10	00935	14589	5	85411	37
24	4 48	55 12	84489	5	15511	99090	10	00910	14601	5	85399	36
25	6 4 40	5 55 20	9.84502	5	10.15498	9.99116	11	10.00884	10 14614	5	9.85386	35
26	4 32	55 28	84515	6	15485	99141	11	00859	14626	5	85374	34
27	4 24	55 36	84528	6	15472	99166	11	00834	14639	6	85361	33
28	4 16	55 44	84540	6	15460	99191	12	00809	14651	6	85349	32
29	4 8	55 52	84553	6	15447	99217	12	00783	14663	6	85337	31
30	6 4 0	5 56 0	9 84566	6	10.15434	9.99242	13	10.00758	10.14676	6	9.85324	30
31	3 52	56 8	84579	7	15421	99267	13	00733	14688	6	85312	29
32	3 44	56 16	84592	7	15408	99293	13	00707	14701	7	85299	28
33	3 36	56 24	84605	7	15395	99318	14	00682	14713	7	85287	27
34	3 28	56 32	84618	7	15382	99343	14	00657	14726	7	85274	26
35	6 3 20	5 56 40	9.84630	8	10.15370	9.99368	15	10.00632	10.14738	7	9.85262	25
36	3 12	56 48	84643	8	15357	99394	15	00606	14750	7	85250	24
37	3 4	56 56	84656	8	15344	99419	16	00581	14763	8	85237	23
38	2 56	57 4	84669	8	15331	99444	16	00556	14775	8	85225	22
39	2 48	57 12	84682	8	15318	99469	16	00531	14788	8	85212	21
40	6 2 40	5 57 20	9.84694	9	10.15306	9.99495	17	10.00505	10.14800	8	9.85200	20
41	2 32	57 28	84707	9	15293	99520	17	00480	14813	8	85187	19
42	2 24	57 36	84720	9	15280	99545	18	00455	14825	9	85175	18
43	2 16	57 44	84733	9	15267	99570	18	00430	14838	9	85162	17
44	2 8	57 52	84745	9	15255	99596	19	00404	14850	9	85150	16
45	6 2 0	5 58 0	9.84758	10	10.15242	9.99621	19	10.00379	10.14863	9	9.85137	15
46	1 52	58 8	84771	10	15229	99646	19	00354	14875	10	85125	14
47	1 44	58 16	84784	10	15216	99672	20	00328	14888	10	85112	13
48	1 36	58 24	84796	10	15204	99697	20	00303	14900	10	85100	12
49	1 28	58 32	84809	11	15191	99722	21	00278	14913	10	85087	11
50	6 1 20	5 58 40	9.84822	11	10.15178	9.99747	21	10.00253	10.14926	10	9.85074	10
51	1 12	58 48	84835	11	15165	99773	21	00227	14938	11	85062	9
52	1 4	58 56	84847	11	15153	99798	22	00202	14951	11	85049	8
53	0 56	59 4	84860	11	15140	99823	22	00177	14963	11	85037	7
54	0 48	59 12	84873	12	15127	99848	23	00152	14976	11	85024	6
55	6 0 40	5 59 20	9.84885	12	10.15115	9.99874	23	10.00126	10.14988	11	9.85012	5
56	0 32	59 28	84898	12	15102	99899	24	00101	15001	12	84999	4
57	0 24	59 36	84911	12	15089	99924	24	00076	15014	12	84986	3
58	0 16	59 44	84923	12	15077	99949	24	00051	15026	12	84974	2
59	0 8	59 52	84936	13	15064	99975	25	00025	15039	12	84961	1
60	0 0	6 0 0	84949	13	15051	10.00000	25	00000	15051	12	84949	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
134°			A		A	B		B	C		C	45

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	3	5	6	8	10	11
	B	3	6	9	13	16	19	22
	C	2	3	5	6	8	9	11

Digitized by Google

TABLES XXVIII, XXIX.

TABLE XXVIII.

For reducing the Time of the Moon's passage over the Meridian of Greenwich, to the Time of its passage over any other Meridian. The numbers taken from this Table are to be added to the Time at Greenwich in West Longitude, but subtracted in East.

Daily Variation of the Moon's passing the Meridian.

Ship's Lon.	40′	42′	44′	46′	48′	50′	52′	54′	56′	58′	60′	62′	64′	66′	Ship's Lon.
°	′	′	′	′	′	′	′	′	′	′	′	′	′	′	°
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5
10	1	1	1	1	1	1	1	1	2	2	2	2	2	2	10
15	2	2	2	2	2	2	2	2	2	2	2	3	3	3	15
20	2	2	2	3	3	3	3	3	3	3	3	3	4	4	20
25	3	3	3	3	3	3	4	4	4	4	4	4	4	5	25
30	3	3	4	4	4	4	4	4	5	5	5	5	5	5	30
35	4	4	4	4	5	5	5	5	5	6	6	6	6	6	35
40	4	5	5	5	5	6	6	6	6	6	7	7	7	7	40
45	5	5	5	6	6	6	6	7	7	7	7	8	8	8	45
50	6	6	6	6	7	7	7	7	8	8	8	9	9	9	50
55	6	6	7	7	7	8	8	8	9	9	9	9	10	10	55
60	7	7	7	8	8	8	9	9	9	10	10	10	11	11	60
65	7	8	8	8	9	9	9	10	10	10	11	11	12	12	65
70	8	8	9	9	9	10	10	10	11	11	12	12	12	13	70
75	8	9	9	10	10	10	11	11	12	12	12	13	13	14	75
80	9	9	10	10	11	11	12	12	12	13	13	14	14	15	80
85	9	10	10	11	11	12	12	13	13	14	14	15	15	16	85
90	10	10	11	11	12	12	13	13	14	14	15	15	16	16	90
95	11	11	12	12	13	13	14	14	15	15	16	16	17	17	95
100	11	12	12	13	13	14	14	15	16	16	17	17	18	18	100
105	12	12	13	13	14	15	15	16	16	17	17	18	19	19	105
110	12	13	13	14	15	15	16	16	17	18	18	19	20	20	110
115	13	13	14	15	15	16	17	17	18	19	19	20	20	21	115
120	13	14	15	15	16	17	17	18	19	19	20	21	21	22	120
125	14	15	15	16	17	17	18	19	19	20	21	22	22	23	125
130	14	15	16	17	17	18	19	19	20	21	22	22	23	24	130
135	15	16	16	17	18	19	19	20	21	22	22	23	24	25	135
140	16	16	17	18	19	19	20	21	22	23	23	24	25	26	140
145	16	17	18	19	19	20	21	22	23	23	24	25	26	27	145
150	17	17	18	19	20	21	22	22	23	24	25	26	27	27	150
155	17	18	19	20	21	22	22	23	24	25	26	27	28	28	155
160	18	19	20	20	21	22	23	24	25	26	27	28	28	29	160
165	18	19	20	21	22	23	24	25	26	27	27	28	29	30	165
170	19	20	21	22	23	24	25	25	26	27	28	29	30	31	170
175	19	20	21	22	23	24	25	26	27	28	29	30	31	32	175
180	20	21	22	23	24	25	26	27	28	29	30	31	32	33	180
	40′	42′	44′	46′	48′	50′	52′	54′	56′	58′	60′	62′	64′	66′	

TABLE XXIX.

Correction of Moon's altitude for Parallax and Refraction.

☽ alt. Deg.	Corr. Min.	☽ alt. Deg.	Corr. Min.
10	51	51	35
11	52	52	35
12	52	53	34
13	52	54	33
14	52	55	32
15	52	56	32
16	52	57	31
17	52	58	30
18	52	59	29
19	52	60	28
20	51		
21	51	61	27
22	51	62	26
23	51	63	26
24	50	64	25
25	50	65	24
26	50	66	23
27	49	67	22
28	49	68	21
29	49	69	20
30	48	70	19
31	48	71	18
32	47	72	17
33	47	73	17
34	46	74	16
35	46	75	15
36	45	76	14
37	45	77	13
38	44	78	12
39	44	79	11
40	43	80	10
41	42	81	9
42	42	82	8
43	41	83	7
44	40	84	6
45	40	85	5
46	39	86	4
47	38	87	3
48	38	88	2
49	37	89	1
50	36	90	0

Digitized by Google

TABLE XXX.

For finding the Variation of the Sun's Right Ascension, of the Declination, of the Equation of Time or of the Moon's Right Ascension, in any number of minutes of time, the Horary Motion being given at the top of the page in seconds, and the number of minutes of time in the side-column;—

Also, for finding the Variation of the Moon's Declination in seconds of time; the motion in one minute being given at the top, and the numbers in the side-column being taken for seconds.

Horary Motion.

M	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″	12″	13″	14″	15″	16″	17″	18″	19″	20″	21″	22″	23″	24″	25″	26″	27″	28″	29″	30″	M
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
3	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3
4	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	4
5	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	3	5
6	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	6
7	0	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	4	7
8	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	4	4	4	4	8
9	0	0	0	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	4	4	4	4	4	4	5	9
10	0	0	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	4	4	4	4	4	4	5	5	5	5	10
11	0	0	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	3	4	4	4	4	4	5	5	5	5	5	6	11
12	0	0	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	4	4	4	4	4	5	5	5	5	5	6	6	6	12
13	0	0	1	1	1	1	2	2	2	2	2	3	3	3	3	3	4	4	4	4	5	5	5	5	5	6	6	6	6	7	13
14	0	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	4	5	5	5	5	6	6	6	6	7	7	7	14
15	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6	6	7	7	7	7	8	15
16	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	5	5	5	5	6	6	6	6	7	7	7	7	8	8	16
17	0	1	1	1	1	2	2	2	3	3	3	3	4	4	4	5	5	5	5	6	6	6	7	7	7	7	8	8	8	9	17
18	0	1	1	1	2	2	2	2	3	3	3	4	4	4	5	5	5	5	6	6	6	7	7	7	8	8	8	8	9	9	18
19	0	1	1	1	2	2	2	3	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9	10	19
20	0	1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9	10	10	20
21	0	1	1	1	2	2	2	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	9	9	9	10	10	11	21
22	0	1	1	1	2	2	3	3	3	4	4	4	5	5	6	6	6	7	7	7	8	8	8	9	9	10	10	10	11	11	22
23	0	1	1	2	2	2	3	3	3	4	4	5	5	5	6	6	7	7	7	8	8	8	9	9	10	10	10	11	11	12	23
24	0	1	1	2	2	2	3	3	4	4	4	5	5	6	6	6	7	7	8	8	8	9	9	10	10	10	11	11	12	12	24
25	0	1	1	2	2	3	3	3	4	4	5	5	5	6	6	7	7	8	8	8	9	9	10	10	10	11	11	12	12	13	25
26	0	1	1	2	2	3	3	3	4	4	5	5	6	6	7	7	7	8	8	9	9	10	10	10	11	11	12	12	13	13	26
27	0	1	1	2	2	3	3	4	4	5	5	5	6	6	7	7	8	8	9	9	9	10	10	11	11	12	12	13	13	14	27
28	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	28
29	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	29
30	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	30
31	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	16	31
32	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	32
33	1	1	2	2	3	3	4	4	5	6	6	7	7	8	8	9	9	10	10	11	12	12	13	13	14	14	15	15	16	17	33
34	1	1	2	2	3	3	4	5	5	6	6	7	7	8	9	9	10	10	11	11	12	12	13	14	14	15	15	16	16	17	34
35	1	1	2	2	3	4	4	5	5	6	6	7	8	8	9	9	10	11	11	12	12	13	13	14	15	15	16	16	17	18	35
36	1	1	2	2	3	4	4	5	5	6	7	7	8	8	9	10	10	11	11	12	13	13	14	14	15	16	16	17	17	18	36
37	1	1	2	2	3	4	4	5	6	6	7	7	8	9	9	10	10	11	12	12	13	14	14	15	15	16	17	17	18	19	37
38	1	1	2	3	3	4	4	5	6	6	7	8	8	9	10	10	11	11	12	13	13	14	15	15	16	16	17	18	18	19	38
39	1	1	2	3	3	4	5	5	6	7	7	8	8	9	10	10	11	12	12	13	14	14	15	16	16	17	18	18	19	20	39
40	1	1	2	3	3	4	5	5	6	7	7	8	9	9	10	11	11	12	13	13	14	15	15	16	17	17	18	19	19	20	40
41	1	1	2	3	3	4	5	5	6	7	8	8	9	10	10	11	12	12	13	14	14	15	16	16	17	18	18	19	20	21	41
42	1	1	2	3	4	4	5	6	6	7	8	8	9	10	11	11	12	13	13	14	15	15	16	17	18	18	19	20	20	21	42
43	1	1	2	3	4	4	5	6	6	7	8	9	9	10	11	11	12	13	14	14	15	16	16	17	18	19	19	20	21	22	43
44	1	1	2	3	4	4	5	6	7	7	8	9	10	10	11	12	12	13	14	15	15	16	17	18	18	19	20	21	21	22	44
45	1	2	2	3	4	5	5	6	7	8	8	9	10	11	11	12	13	14	14	15	16	17	17	18	19	20	20	21	22	23	45
46	1	2	2	3	4	5	5	6	7	8	8	9	10	11	12	12	13	14	15	15	16	17	18	18	19	20	21	21	22	23	46
47	1	2	2	3	4	5	5	6	7	8	9	9	10	11	12	13	13	14	15	16	16	17	18	19	20	20	21	22	23	24	47
48	1	2	2	3	4	5	6	6	7	8	9	10	10	11	12	13	14	14	15	16	17	18	18	19	20	21	22	22	23	24	48
49	1	2	2	3	4	5	6	7	7	8	9	10	11	11	12	13	14	15	16	16	17	18	19	20	20	21	22	23	24	25	49
50	1	2	3	3	4	5	6	7	8	8	9	10	11	12	13	13	14	15	16	17	18	18	19	20	21	22	23	23	24	25	50
51	1	2	3	3	4	5	6	7	8	9	9	10	11	12	13	14	14	15	16	17	18	19	20	20	21	22	23	24	25	26	51
52	1	2	3	3	4	5	6	7	8	9	10	10	11	12	13	14	15	16	16	17	18	19	20	21	22	23	23	24	25	26	52
53	1	2	3	4	4	5	6	7	8	9	10	11	11	12	13	14	15	16	17	18	19	19	20	21	22	23	24	25	26	27	53
54	1	2	3	4	5	5	6	7	8	9	10	11	12	13	14	14	15	16	17	18	19	20	21	22	23	23	24	25	26	27	54
55	1	2	3	4	5	6	6	7	8	9	10	11	12	13	14	15	16	17	17	18	19	20	21	22	23	24	25	26	27	28	55
56	1	2	3	4	5	6	7	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	21	22	23	24	25	26	27	28	56
57	1	2	3	4	5	6	7	8	9	10	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	57
58	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	58
59	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	59
60	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	60

Digitized by Google

TABLE XXX.

For finding the Variation of the Sun's Right Ascension, of the Declination, of the Equation of Time or of the Moon's Right Ascension, in any number of minutes of time, the Hora'y Motion being given at the top of the page in seconds, and the number of minutes of time in the side-column;—

Also, for finding the Variation of the Moon's Declination in seconds of time; the motion in one minute being given at the top, and the numbers in the side-column being taken for seconds.

Horary Motion.

M	31″	32″	33″	34″	35″	36″	37″	38″	39″	40″	41″	42″	43″	44″	45″	46″	47″	48″	49″	50″	51″	52″	53″	54″	55″	56″	57″	58″	59″	60″	M
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
4	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4
5	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5
6	3	3	3	3	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6
7	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	7	7	7	7	7	7
8	4	4	4	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	8	8	8	8	8
9	5	5	5	5	5	5	6	6	6	6	6	6	6	7	7	7	7	7	7	8	8	8	8	8	8	8	9	9	9	9	9
10	5	5	6	6	6	6	6	6	7	7	7	7	7	7	8	8	8	8	8	8	9	9	9	9	9	9	10	10	10	10	10
11	6	6	6	6	6	7	7	7	7	7	8	8	8	8	8	8	9	9	9	9	9	10	10	10	10	10	10	11	11	11	11
12	6	6	7	7	7	7	7	8	8	8	8	8	9	9	9	9	9	10	10	10	10	10	11	11	11	11	11	12	12	12	12
13	7	7	7	7	8	8	8	8	8	9	9	9	9	10	10	10	10	10	11	11	11	11	11	12	12	12	12	13	13	13	13
14	7	7	8	8	8	8	9	9	9	9	10	10	10	10	11	11	11	11	11	12	12	12	12	13	13	13	13	14	14	14	14
15	8	8	8	9	9	9	9	10	10	10	10	11	11	11	11	12	12	12	12	13	13	13	13	14	14	14	14	15	15	15	15
16	8	9	9	9	9	10	10	10	10	11	11	11	11	12	12	12	13	13	13	13	14	14	14	14	15	15	15	15	16	16	16
17	9	9	9	10	10	10	10	11	11	11	12	12	12	12	13	13	13	14	14	14	14	15	15	15	16	16	16	16	17	17	17
18	9	10	10	10	11	11	11	11	12	12	12	13	13	13	14	14	14	14	15	15	15	16	16	16	17	17	17	17	18	18	18
19	10	10	10	11	11	11	12	12	12	13	13	13	14	14	14	15	15	15	16	16	16	16	17	17	17	18	18	18	19	19	19
20	10	11	11	11	12	12	12	13	13	13	14	14	14	15	15	15	16	16	16	17	17	17	18	18	18	19	19	19	20	20	20
21	11	11	12	12	12	13	13	13	14	14	14	15	15	15	16	16	16	17	17	18	18	18	19	19	19	20	20	20	21	21	21
22	11	12	12	12	13	13	14	14	14	15	15	15	16	16	17	17	17	18	18	18	19	19	19	20	20	21	21	21	22	22	22
23	12	12	13	13	13	14	14	15	15	15	16	16	16	17	17	18	18	18	19	19	20	20	20	21	21	21	22	22	23	23	23
24	12	13	13	14	14	14	15	15	16	16	16	17	17	18	18	18	19	19	20	20	20	21	21	22	22	22	23	23	24	24	24
25	13	13	14	14	15	15	15	16	16	17	17	18	18	18	19	19	20	20	20	21	21	22	22	23	23	23	24	24	25	25	25
26	13	14	14	15	15	16	16	16	17	17	18	18	19	19	20	20	20	21	21	22	22	23	23	23	24	24	25	25	26	26	26
27	14	14	15	15	16	16	17	17	18	18	18	19	19	20	20	21	21	22	22	23	23	23	24	24	25	25	26	26	27	27	27
28	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	28
29	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	29
30	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	30
31	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31
32	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31	32	32
33	17	18	18	19	19	20	20	21	21	22	23	23	24	24	25	25	26	26	27	28	28	29	29	30	30	31	31	32	32	33	33
34	18	18	19	19	20	20	21	22	22	23	23	24	24	25	26	26	27	27	28	28	29	29	30	31	31	32	32	33	33	34	34
35	18	19	19	20	20	21	22	22	23	23	24	25	25	26	26	27	27	28	29	29	30	30	31	32	32	33	33	34	34	35	35
36	19	19	20	20	21	22	22	23	23	24	25	25	26	26	27	28	28	29	29	30	31	31	32	32	33	34	34	35	35	36	36
37	19	20	20	21	22	22	23	23	24	25	25	26	27	27	28	28	29	30	30	31	31	32	33	33	34	35	35	36	36	37	37
38	20	20	21	22	22	23	23	24	25	25	26	27	27	28	29	29	30	30	31	32	32	33	34	34	35	35	36	37	37	38	38
39	20	21	21	22	23	23	24	25	25	20	27	27	28	29	29	30	31	31	32	33	33	34	34	35	36	36	37	38	38	39	39
40	21	21	22	23	23	24	25	25	26	27	27	28	29	29	30	31	31	32	33	33	34	35	35	36	37	37	38	39	39	40	40
41	21	22	23	23	24	25	25	26	27	27	28	29	29	30	31	31	32	33	33	34	35	36	36	37	38	38	39	40	40	41	41
42	22	22	23	24	25	25	26	27	27	28	29	29	30	31	32	32	33	34	34	35	36	36	37	38	39	39	40	41	41	42	42
43	22	23	24	24	25	26	27	27	28	29	29	30	31	32	32	33	34	34	35	36	37	37	38	39	39	40	41	42	42	43	43
44	23	23	24	25	26	26	27	28	29	29	30	31	32	32	33	34	34	35	36	37	37	38	39	40	40	41	42	43	43	44	44
45	23	24	25	26	26	27	28	29	29	30	31	32	32	33	34	35	35	36	37	38	38	39	40	41	41	42	43	44	44	45	45
46	24	25	25	26	27	28	28	29	30	31	31	32	33	34	35	35	36	37	38	38	39	40	41	41	42	43	44	44	45	46	46
47	24	25	26	27	27	28	29	30	31	31	32	33	34	34	35	36	37	38	38	39	40	41	42	42	43	44	45	45	46	47	47
48	25	26	26	27	28	29	30	30	31	32	33	34	34	35	36	37	38	38	39	40	41	42	42	43	44	45	46	46	47	48	48
49	25	26	27	28	29	29	30	31	32	33	33	34	35	36	37	38	38	39	40	41	42	42	43	44	45	46	47	47	48	49	49
50	26	27	28	28	29	30	31	32	33	33	34	35	36	37	38	38	39	40	41	42	43	43	44	45	46	47	48	48	49	50	50
51	26	27	28	29	30	31	31	32	33	34	35	36	37	37	38	39	40	41	42	43	43	44	45	46	47	48	48	49	50	51	51
52	27	28	29	29	30	31	32	33	34	35	36	36	37	38	39	40	41	42	42	43	44	45	46	47	48	49	49	50	51	52	52
53	27	28	29	30	31	32	33	34	34	35	36	37	38	39	40	41	42	42	43	44	45	46	47	48	49	49	50	51	52	53	53
54	28	29	30	31	32	32	33	34	35	36	37	38	39	40	41	41	42	43	44	45	46	47	48	49	50	50	51	52	53	54	54
55	28	29	30	31	32	33	34	35	36	37	38	39	39	40	41	42	43	44	45	46	47	48	49	50	50	51	52	53	54	55	55
56	29	30	31	32	33	34	35	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	49	50	51	52	53	54	55	56	56
57	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	48	49	50	51	52	53	54	55	56	57	57
58	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	58
59	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	59
60	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	60

Digitized by Google

TABLE XXX.

For finding the Variation of the Sun's Right Ascension, of the Declination, of the Equation of Time or of the Moon's Right Ascension, in any number of minutes of time, the Horary Motion being given at the top of the page in seconds, and the number of minutes of time in the side-column ;—

Also, for finding the Variation of the Moon's Declination in seconds of time; the motion in one minute being given at the top, and the numbers in the side-column being taken for seconds.

Horary Motion.

M	61″	62″	63″	64″	65″	66″	67″	68″	69″	70″	71″	72″	73″	74″	75″	76″	77″	78″	79″	80″	81″	82″	83″	84″	85″	86″	87″	88″	89″	90″	M
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2
3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	3
4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	4
5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7	8	5
6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	6
7	7	7	7	7	8	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	10	11	7
8	8	8	8	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	12	12	12	12	8
9	9	9	9	10	10	10	10	10	10	11	11	11	11	11	11	11	12	12	12	12	12	12	12	13	13	13	13	13	13	14	9
10	10	10	11	11	11	11	11	11	12	12	12	12	12	12	13	13	13	13	13	13	14	14	14	14	14	14	15	15	15	15	10
11	11	11	12	12	12	12	12	12	13	13	13	13	13	14	14	14	14	14	14	15	15	15	15	15	16	16	16	16	16	17	11
12	12	12	13	13	13	13	13	14	14	14	14	14	15	15	15	15	15	16	16	16	16	16	17	17	17	17	17	18	18	18	12
13	13	13	14	14	14	14	15	15	15	15	15	16	16	16	16	16	17	17	17	17	18	18	18	18	18	19	19	19	19	20	13
14	14	14	15	15	15	15	16	16	16	16	17	17	17	17	18	18	18	18	18	19	19	19	19	20	20	20	20	21	21	21	14
15	15	16	16	16	16	17	17	17	17	18	18	18	18	19	19	19	19	20	20	20	20	21	21	21	21	22	22	22	22	23	15
16	16	17	17	17	17	18	18	18	18	19	19	19	19	20	20	20	21	21	21	21	22	22	22	22	23	23	23	23	24	24	16
17	17	18	18	18	18	19	19	19	20	20	20	20	21	21	21	22	22	22	22	23	23	23	24	24	24	24	25	25	25	26	17
18	18	19	19	19	20	20	20	20	21	21	21	22	22	22	23	23	23	23	24	24	24	25	25	25	26	26	26	26	27	27	18
19	19	20	20	20	21	21	21	22	22	22	22	23	23	23	24	24	24	25	25	25	26	26	26	27	27	27	28	28	28	29	19
20	20	21	21	21	22	22	22	23	23	23	24	24	24	25	25	25	26	26	26	27	27	27	28	28	28	29	29	29	30	30	20
21	21	22	22	22	23	23	23	24	24	25	25	25	26	26	26	27	27	27	28	28	28	29	29	29	30	30	30	31	31	32	21
22	22	23	23	23	24	24	25	25	25	26	26	26	27	27	28	28	28	29	29	29	30	30	30	31	31	32	32	32	33	33	22
23	23	24	24	25	25	25	26	26	26	27	27	28	28	28	29	29	30	30	30	31	31	31	32	32	33	33	33	34	34	35	23
24	24	25	25	26	26	26	27	27	28	28	28	29	29	30	30	30	31	31	32	32	32	33	33	34	34	34	34	35	36	36	24
25	25	26	26	27	27	28	28	28	29	29	30	30	30	31	31	32	32	33	33	33	34	34	35	35	35	36	36	37	37	38	25
26	26	27	27	28	28	29	29	29	30	30	31	31	32	32	33	33	33	34	34	35	35	36	36	36	37	37	38	38	39	39	26
27	27	28	28	29	29	30	30	31	31	32	32	32	33	33	34	34	35	35	36	36	36	37	37	38	38	39	39	40	40	41	27
28	28	29	29	30	30	31	31	32	32	33	33	34	34	35	35	35	36	36	37	37	38	38	39	39	40	40	41	41	42	42	28
29	29	30	30	31	31	32	32	33	33	34	34	35	35	36	36	37	37	38	38	39	39	40	40	41	41	42	42	43	43	44	29
30	31	31	32	32	33	33	34	34	35	35	36	36	37	37	38	38	39	39	40	40	41	41	42	42	43	43	44	44	45	45	30
31	32	32	33	33	34	34	35	35	36	36	37	37	38	38	39	39	40	40	41	41	42	42	43	43	44	44	45	45	46	47	31
32	33	33	34	34	35	35	36	36	37	37	38	38	39	39	40	41	41	42	42	43	43	44	44	45	45	46	46	47	47	48	32
33	34	34	35	35	36	36	37	37	38	39	39	40	40	41	41	42	42	43	43	44	45	45	46	46	47	47	48	48	49	50	33
34	35	35	36	36	37	37	38	39	39	40	40	41	41	42	43	43	44	44	45	45	46	46	47	48	48	49	49	50	50	51	34
35	36	36	37	37	38	39	39	40	40	41	41	42	43	43	44	44	45	46	46	47	47	48	48	49	50	50	51	51	52	53	35
36	37	37	38	38	39	40	40	41	41	42	43	43	44	44	45	46	46	47	47	48	49	49	50	50	51	52	52	53	53	54	36
37	38	38	39	39	40	41	41	42	43	43	44	44	45	46	46	47	47	48	49	49	50	51	51	52	52	53	54	54	55	56	37
38	39	39	40	41	41	42	42	43	44	44	45	46	46	47	48	48	49	49	50	51	51	52	53	53	54	54	55	56	56	57	38
39	40	40	41	42	42	43	44	44	45	46	46	47	47	48	49	49	50	51	51	52	53	53	54	55	55	56	57	57	58	59	39
40	41	41	42	43	43	44	45	45	46	47	47	48	49	49	50	51	51	52	53	53	54	55	55	56	57	57	58	59	59	60	40
41	42	42	43	44	44	45	46	46	47	48	49	49	50	51	51	52	53	53	54	55	55	56	57	57	58	59	59	60	61	62	41
42	43	43	44	45	46	46	47	48	48	49	50	50	51	52	53	53	54	55	55	56	57	57	58	59	60	60	61	62	62	63	42
43	44	44	45	46	47	47	48	49	49	50	51	52	52	53	54	54	55	56	57	57	58	59	59	60	61	62	62	63	64	65	43
44	45	45	46	47	48	48	49	50	51	51	52	53	54	54	55	56	56	57	58	59	59	60	61	62	62	63	64	65	65	66	44
45	46	47	47	48	49	50	50	51	52	53	53	54	55	56	56	57	58	59	59	60	61	62	62	63	64	65	65	66	67	68	45
46	47	48	48	49	50	51	51	52	53	54	54	55	56	57	58	58	59	60	61	61	62	63	64	64	65	66	67	67	68	69	46
47	48	49	49	50	51	52	52	53	54	55	56	56	57	58	59	60	60	61	62	63	63	64	65	66	67	67	68	69	70	71	47
48	49	50	50	51	52	53	54	54	55	56	57	58	58	59	60	61	62	62	63	64	65	66	66	67	68	69	70	70	71	72	48
49	50	51	51	52	53	54	55	56	56	57	58	59	60	60	61	62	63	64	65	65	66	67	68	69	69	70	71	72	73	74	49
50	51	52	53	53	54	55	56	57	58	58	59	60	61	62	63	63	64	65	66	67	68	68	69	70	71	72	73	73	74	75	50
51	52	53	54	54	55	56	57	58	59	60	60	61	62	63	64	65	65	66	67	68	69	70	71	71	72	73	74	75	76	77	51
52	53	54	55	55	56	57	58	59	60	61	62	62	63	64	65	66	67	68	68	69	70	71	72	73	74	75	75	76	77	78	52
53	54	55	56	57	57	58	59	60	61	62	63	64	64	65	66	67	68	69	70	71	72	72	73	74	75	76	77	78	79	80	53
54	55	56	57	58	59	59	60	61	62	63	64	65	66	67	68	68	69	70	71	72	73	74	75	76	77	77	78	79	80	81	54
55	56	57	58	59	60	61	61	62	63	64	65	66	67	68	69	70	71	72	72	73	74	75	76	77	78	79	80	81	82	83	55
56	57	58	59	60	61	62	63	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	77	78	79	80	81	82	83	84	56
57	58	59	60	61	62	63	64	65	66	67	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	57
58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	58
59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	59
60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	60

Digitized by Google

TABLE XXX.

For finding the Variation of the Sun's Right Ascension, of the Declination, of the Equation of Time or of the Moon's Right Ascension, in any number of minutes of time, the Horary Motion being given at the top of the page in seconds, and the number of minutes of time in the side-column;—

Also, for finding the Variation of the Moon's Declination in seconds of time; the motion in one minute being given at the top, and the numbers in the side-column being taken for seconds.

Horary Motion.

M	91″	92″	93″	94″	95″	96″	97″	98″	99″	100″	101″	102″	103″	104″	105″	106″	107″	108″	109″	110″	111″	112″	113″	114″	115″	M
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	2
3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	3
4	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	8	8	8	4
5	8	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9	9	9	9	9	10	10	5
6	9	9	9	9	10	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	12	6
7	11	11	11	11	11	11	11	11	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	7
8	12	12	12	13	13	13	13	13	13	13	13	14	14	14	14	14	14	14	15	15	15	15	15	15	15	8
9	14	14	14	14	14	14	15	15	15	15	15	15	15	16	16	16	16	16	16	17	17	17	17	17	17	9
10	15	15	16	16	16	16	16	16	17	17	17	17	17	17	18	18	18	18	18	18	19	19	19	19	19	10
11	17	17	17	17	17	18	18	18	18	18	19	19	19	19	19	19	20	20	20	20	20	21	21	21	21	11
12	18	18	19	19	19	19	19	20	20	20	20	20	21	21	21	21	21	22	22	22	22	22	23	23	23	12
13	20	20	20	20	21	21	21	21	21	22	22	22	22	23	23	23	23	23	24	24	24	24	24	25	25	13
14	21	21	22	22	22	22	23	23	23	23	24	24	24	24	25	25	25	25	25	26	26	26	26	27	27	14
15	23	23	23	24	24	24	24	25	25	25	25	26	26	26	26	27	27	27	27	28	28	28	28	29	29	15
16	24	25	25	25	25	26	26	26	26	27	27	27	27	28	28	28	29	29	29	29	30	30	30	30	31	16
17	26	26	26	27	27	27	27	28	28	28	29	29	29	29	30	30	30	31	31	31	31	32	32	32	33	17
18	27	28	28	28	29	29	29	29	30	30	30	31	31	31	32	32	32	32	33	33	33	34	34	34	35	18
19	29	29	29	30	30	30	31	31	31	32	32	32	33	33	33	34	34	34	35	35	35	35	36	36	36	19
20	30	31	31	31	32	32	32	33	33	33	34	34	34	35	35	35	36	36	36	37	37	37	38	38	38	20
21	32	32	33	33	33	34	34	34	35	35	35	36	36	36	37	37	37	38	38	39	39	39	40	40	40	21
22	33	34	34	34	35	35	36	36	36	37	37	37	38	38	39	39	39	40	40	40	41	41	41	42	42	22
23	35	35	36	36	36	37	37	38	38	38	39	39	39	40	40	41	41	41	42	42	43	43	43	44	44	23
24	36	37	37	38	38	38	39	39	40	40	40	41	41	42	42	42	43	43	44	44	44	45	45	46	46	24
25	38	38	39	39	40	40	40	41	41	42	42	43	43	43	44	44	45	45	45	46	46	47	47	48	48	25
26	39	40	40	41	41	42	42	42	43	43	44	44	45	45	46	46	46	47	47	48	48	49	49	49	50	26
27	41	41	42	42	43	43	44	44	45	45	45	46	46	47	47	48	48	49	49	50	50	50	51	51	52	27
28	42	43	43	44	44	45	45	46	46	47	47	48	48	49	49	49	50	50	51	51	52	52	53	53	54	28
29	44	44	45	45	46	46	47	47	48	48	49	49	50	50	51	51	52	52	53	53	54	54	55	55	56	29
30	46	46	47	47	48	48	49	49	50	50	51	51	52	52	53	53	54	54	55	55	56	56	57	57	58	30
31	47	48	48	49	49	50	50	51	51	52	52	53	53	54	54	55	55	56	56	57	57	58	58	59	59	31
32	49	49	50	50	51	51	52	52	53	53	54	54	55	55	56	57	57	58	58	59	59	60	60	61	61	32
33	50	51	51	52	52	53	53	54	54	55	56	56	57	57	58	58	59	59	60	61	61	62	62	63	63	33
34	52	52	53	53	54	54	55	56	56	57	57	58	58	59	60	60	61	61	62	62	63	63	64	65	65	34
35	53	54	54	55	55	56	57	57	58	58	59	60	60	61	61	62	62	63	64	64	65	65	66	67	67	35
36	55	55	56	56	57	58	58	59	59	60	61	61	62	62	63	64	64	65	65	66	67	67	68	68	69	36
37	56	57	57	58	59	59	60	60	61	62	62	63	64	64	65	65	66	67	67	68	68	69	70	70	71	37
38	58	58	59	60	60	61	61	62	63	63	64	65	65	66	67	67	68	68	69	70	70	71	72	72	73	38
39	59	60	60	61	62	62	63	64	64	65	66	66	67	68	68	69	70	70	71	72	72	73	73	74	75	39
40	61	61	62	63	63	64	65	65	66	67	67	68	69	69	70	71	71	72	73	73	74	75	75	76	77	40
41	62	63	64	64	65	66	66	67	68	68	69	70	70	71	72	72	73	74	74	75	76	77	77	78	79	41
42	64	64	65	66	67	67	68	69	69	70	71	71	72	73	74	74	75	76	76	77	78	78	79	80	81	42
43	65	66	67	67	68	69	70	70	71	72	72	73	74	75	75	76	77	77	78	79	80	80	81	82	82	43
44	67	67	68	69	70	70	71	72	73	73	74	75	76	76	77	78	78	79	80	81	81	82	83	84	84	44
45	68	69	70	71	71	72	73	74	74	75	76	77	77	78	79	80	80	81	82	83	83	84	85	86	86	45
46	70	71	71	72	73	74	74	75	76	77	77	78	79	80	81	81	82	83	84	84	85	86	87	87	88	46
47	71	72	73	74	74	75	76	77	78	78	79	80	81	81	82	83	84	85	85	86	87	88	89	89	90	47
48	73	74	74	75	76	77	78	78	79	80	81	82	82	83	84	85	86	86	87	88	89	90	90	91	92	48
49	74	75	76	77	78	78	79	80	81	82	82	83	84	85	86	87	87	88	89	90	91	91	92	93	94	49
50	76	77	78	78	79	80	81	82	83	83	84	85	86	87	88	88	89	90	91	92	93	93	94	95	96	50
51	77	78	79	80	81	82	82	83	84	85	86	87	88	88	89	90	91	92	93	94	94	95	96	97	98	51
52	79	80	81	81	82	83	84	85	86	87	88	88	89	90	91	92	93	94	94	95	96	97	98	99	100	52
53	80	81	82	83	84	85	86	87	87	88	89	90	91	92	93	94	95	95	96	97	98	99	100	101	102	53
54	82	83	84	85	86	86	87	88	89	90	91	92	93	94	95	95	96	97	98	99	100	101	102	103	104	54
55	83	84	85	86	87	88	89	90	91	92	93	94	94	95	96	97	98	99	100	101	102	103	104	105	105	55
56	85	86	87	88	89	90	91	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	105	106	107	56
57	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	105	106	107	108	109	57
58	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	102	103	104	105	106	107	108	109	110	111	58
59	90	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	59
60	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	60

Digitized by Google

TABLE XXX.

For finding the Variation of the Sun's Right Ascension, of the Declination, of the Equation of Time or of the Moon's Right Ascension, in any number of minutes of time, the Horary Motion being given at the top of the page in seconds, and the number of minutes of time in the side-column;—

Also, for finding the Variation of the Moon's Declination in seconds of time; the motion in one minute being given at the top, and the numbers in the side-column being taken for seconds.

Horary Motion.

M	116″	117″	118″	119″	120″	121″	122″	123″	124″	125″	126″	127″	128″	129″	130″	131″	132″	133″	134″	135″	136″	137″	138″	M
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	2
3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	7	3
4	8	8	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9	9	9	9	4
5	10	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	11	11	12	5
6	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	14	14	14	14	6
7	14	14	14	14	14	14	14	14	14	15	15	15	15	15	15	15	15	16	16	16	16	16	16	7
8	15	16	16	16	16	16	16	16	17	17	17	17	17	17	17	17	18	18	18	18	18	18	18	8
9	17	18	18	18	18	18	18	18	19	19	19	19	19	19	20	20	20	20	20	20	20	21	21	9
10	19	20	20	20	20	20	20	21	21	21	21	21	21	22	22	22	22	22	22	23	23	23	23	10
11	21	21	22	22	22	22	22	23	23	23	23	23	23	24	24	24	24	24	25	25	25	25	25	11
12	23	23	24	24	24	24	24	25	25	25	25	25	26	26	26	26	26	27	27	27	27	27	28	12
13	25	25	26	26	26	26	26	27	27	27	27	28	28	28	28	28	29	29	29	29	29	30	30	13
14	27	27	28	28	28	28	28	29	29	29	29	30	30	30	30	31	31	31	31	32	32	32	32	14
15	29	29	30	30	30	30	31	31	31	31	32	32	32	32	33	33	33	33	34	34	34	34	35	15
16	31	31	31	32	32	32	33	33	33	33	34	34	34	34	35	35	35	35	36	36	36	37	37	16
17	33	33	33	34	34	34	35	35	35	35	36	36	36	37	37	37	37	38	38	38	39	39	39	17
18	35	35	35	36	36	36	37	37	37	38	38	38	38	39	39	39	40	40	40	41	41	41	41	18
19	37	37	37	38	38	38	39	39	39	40	40	40	41	41	41	41	42	42	42	43	43	43	44	19
20	39	39	39	40	40	40	41	41	41	42	42	42	43	43	43	44	44	44	45	45	45	46	46	20
21	41	41	41	42	42	42	43	43	43	44	44	44	45	45	46	46	46	47	47	47	48	48	48	21
22	43	43	43	44	44	44	45	45	45	46	46	47	47	47	48	48	48	49	49	50	50	50	51	22
23	44	45	45	46	46	46	47	47	48	48	48	49	49	49	50	50	51	51	51	52	52	53	53	23
24	46	47	47	48	48	48	49	49	50	50	50	51	51	52	52	52	53	53	54	54	54	55	55	24
25	48	49	49	50	50	50	51	51	52	52	53	53	53	54	54	55	55	55	56	56	57	57	58	25
26	50	51	51	52	52	52	53	53	54	54	55	55	55	56	56	57	57	58	58	59	59	59	60	26
27	52	53	53	54	54	54	55	55	56	56	57	57	58	58	59	59	59	60	60	61	61	62	62	27
28	54	55	55	56	56	56	57	57	58	58	59	59	60	60	61	61	62	62	63	63	63	64	64	28
29	56	57	57	58	58	58	59	59	60	60	61	61	62	62	63	63	64	64	65	65	66	66	67	29
30	58	59	59	60	60	61	61	62	62	63	63	64	64	65	65	66	66	67	67	68	68	69	69	30
31	60	60	61	61	62	63	63	64	64	65	65	66	66	67	67	68	68	69	69	70	70	71	71	31
32	62	62	63	63	64	65	65	66	66	67	67	68	68	69	69	70	70	71	71	72	73	73	74	32
33	64	64	65	65	66	67	67	68	68	69	69	70	70	71	72	72	73	73	74	74	75	75	76	33
34	66	66	67	67	68	69	69	70	70	71	71	72	73	73	74	74	75	75	76	77	77	78	78	34
35	68	68	69	69	70	71	71	72	72	73	74	74	75	75	76	76	77	78	78	79	79	80	81	35
36	70	70	71	71	72	73	73	74	74	75	76	76	77	77	78	79	79	80	80	81	82	82	83	36
37	72	72	73	73	74	75	75	76	76	77	78	78	79	80	80	81	81	82	83	83	84	84	85	37
38	73	74	75	75	76	77	77	78	79	79	80	80	81	82	82	83	84	84	85	86	86	87	87	38
39	75	76	77	77	78	79	79	80	81	81	82	83	83	84	85	85	86	86	87	88	88	89	90	39
40	77	78	79	79	80	81	81	82	83	83	84	85	85	86	87	87	88	89	89	90	91	91	92	40
41	79	80	81	81	82	83	83	84	85	85	86	87	87	88	89	90	90	91	92	92	93	94	94	41
42	81	82	83	83	84	85	85	86	87	88	88	89	90	90	91	92	92	93	94	95	95	96	97	42
43	83	84	85	85	86	87	87	88	89	90	90	91	92	92	93	94	95	95	96	97	97	98	99	43
44	85	86	87	87	88	89	89	90	91	92	92	93	94	95	95	96	97	98	98	99	100	100	101	44
45	87	88	89	89	90	91	92	92	93	94	95	95	96	97	98	98	99	100	101	101	102	103	104	45
46	89	90	90	91	92	93	94	94	95	96	97	97	98	99	100	100	101	102	103	104	104	105	106	46
47	91	92	92	93	94	95	96	96	97	98	99	99	100	101	102	103	103	104	105	106	107	107	108	47
48	93	94	94	95	96	97	98	98	99	100	101	102	102	103	104	105	106	106	107	108	109	110	110	48
49	95	96	96	97	98	99	100	100	101	102	103	104	105	105	106	107	108	109	109	110	111	112	113	49
50	97	98	98	99	100	101	102	103	103	104	105	106	107	108	108	109	110	111	112	113	113	114	115	50
51	99	99	100	101	102	103	104	105	105	106	107	108	109	110	111	111	112	113	114	115	116	116	117	51
52	101	101	102	103	104	105	106	107	107	108	109	110	111	112	113	114	114	115	116	117	118	119	120	52
53	102	103	104	105	106	107	108	109	110	110	111	112	113	114	115	116	117	117	118	119	120	121	122	53
54	104	105	106	107	108	109	110	111	112	113	113	114	115	116	117	118	119	120	121	122	122	123	124	54
55	106	107	108	109	110	111	112	113	114	115	116	116	117	118	119	120	121	122	123	124	125	126	127	55
56	108	109	110	111	112	113	114	115	116	117	118	119	119	120	121	122	123	124	125	126	127	128	129	56
57	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	124	125	126	127	128	129	130	131	57
58	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	131	132	133	58
59	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	59
60	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	60

Digitized by Google

TABLE XXX.

For finding the Variation of the Sun's Right Ascension, of the Declination, of the Equation of Time or of the Moon's Right Ascension, in any number of minutes of time, the Horary Motion being given at the top of the page in seconds, and the number of minutes of time in the side-column;—

Also, for finding the Variation of the Moon's Declination in seconds of time; the motion in one minute being given at the top, and the numbers in the side-column being taken for seconds.

Horary Motion.

M	″ 139	″ 140	″ 141	″ 142	″ 143	″ 144	″ 145	″ 146	″ 147	″ 148	″ 149	″ 150	″ 151	″ 152	″ 153	″ 154	″ 155	″ 156	″ 157	″ 158	″ 159	″ 160	M
1	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	1
2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2
3	7	7	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	8	8	3
4	9	9	9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	11	11	4
5	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	13	5
6	14	14	14	14	14	14	15	15	15	15	15	15	15	15	15	15	16	16	16	16	16	16	6
7	16	16	16	17	17	17	17	17	17	17	17	18	18	18	18	18	18	18	18	18	19	19	7
8	19	19	19	19	19	19	19	19	20	20	20	20	20	20	20	21	21	21	21	21	21	21	8
9	21	21	21	21	21	22	22	22	22	22	22	23	23	23	23	23	23	23	24	24	24	24	9
10	23	23	24	24	24	24	24	24	25	25	25	25	25	25	26	26	26	26	26	26	27	27	10
11	25	26	26	26	26	26	27	27	27	27	27	28	28	28	28	28	28	29	29	29	29	29	11
12	28	28	28	28	29	29	29	29	29	30	30	30	30	30	31	31	31	31	31	32	32	32	12
13	30	30	31	31	31	31	31	32	32	32	32	33	33	33	33	33	34	34	34	34	34	35	13
14	32	33	33	33	33	34	34	34	34	35	35	35	35	35	36	36	36	36	37	37	37	37	14
15	35	35	35	36	36	36	36	37	37	37	37	38	38	38	38	39	39	39	39	40	40	40	15
16	37	37	38	38	38	38	39	39	39	39	40	40	40	41	41	41	41	42	42	42	42	43	16
17	39	40	40	40	41	41	41	41	42	42	42	43	43	43	43	44	44	44	44	45	45	45	17
18	42	42	42	43	43	43	44	44	44	44	45	45	45	46	46	46	47	47	47	47	48	48	18
19	44	44	45	45	45	46	46	46	47	47	47	48	48	48	48	49	49	49	50	50	50	51	19
20	46	47	47	47	48	48	48	49	49	49	50	50	50	51	51	51	52	52	52	53	53	53	20
21	49	49	49	50	50	50	51	51	51	52	52	53	53	53	54	54	54	55	55	55	56	56	21
22	51	51	52	52	52	53	53	54	54	54	55	55	55	56	56	56	57	57	58	58	58	59	22
23	53	54	54	54	55	55	56	56	56	57	57	58	58	58	59	59	59	60	60	61	61	61	23
24	56	56	56	57	57	58	58	58	59	59	60	60	60	61	61	62	62	62	63	63	64	64	24
25	58	58	59	59	60	60	60	61	61	62	62	63	63	63	64	64	65	65	65	66	66	67	25
26	60	61	61	62	62	62	63	63	64	64	65	65	65	66	66	67	67	68	68	68	69	69	26
27	63	63	63	64	64	65	65	66	66	67	67	68	68	68	69	69	70	70	71	71	72	72	27
28	65	65	66	66	67	67	68	68	69	69	70	70	70	71	71	72	72	73	73	74	74	75	28
29	67	68	68	69	69	70	70	71	71	72	72	73	73	73	74	74	75	75	76	76	77	77	29
30	70	70	71	71	72	72	73	73	74	74	75	75	76	76	77	77	78	78	79	79	80	80	30
31	72	72	73	73	74	74	75	75	76	76	77	78	78	79	79	80	80	81	81	82	82	83	31
32	74	75	75	76	76	77	77	78	78	79	79	80	81	81	82	82	83	83	84	84	85	85	32
33	76	77	78	78	79	79	80	80	81	81	82	83	83	84	84	85	85	86	86	87	87	88	33
34	79	79	80	80	81	82	82	83	83	84	84	85	86	86	87	87	88	88	89	90	90	91	34
35	81	82	82	83	83	84	85	85	86	86	87	88	88	89	89	90	90	91	92	92	93	93	35
36	83	84	85	85	86	86	87	88	88	89	89	90	91	91	92	92	93	94	94	95	95	96	36
37	86	86	87	88	88	89	89	90	91	91	92	93	93	94	94	95	96	96	97	97	98	99	37
38	88	89	89	90	91	91	92	92	93	94	94	95	96	96	97	98	98	99	99	100	101	101	38
39	90	91	92	92	93	94	94	95	96	96	97	98	98	99	99	100	101	101	102	103	103	104	39
40	93	93	94	95	95	96	97	97	98	99	99	100	101	101	102	103	103	104	105	105	106	107	40
41	95	96	96	97	98	98	99	100	100	101	102	103	103	104	105	105	106	107	107	108	109	109	41
42	97	98	99	99	100	101	102	102	103	104	104	105	106	106	107	108	109	109	110	111	111	112	42
43	100	100	101	102	102	103	104	105	105	106	107	108	108	109	110	110	111	112	113	113	114	115	43
44	102	103	103	104	105	106	106	107	108	109	109	110	111	111	112	113	114	114	115	116	117	117	44
45	104	105	106	107	107	108	109	110	110	111	112	113	113	114	115	116	116	117	118	119	119	120	45
46	107	107	108	109	110	110	111	112	113	113	114	115	116	117	117	118	119	120	120	121	122	123	46
47	109	110	110	111	112	113	114	114	115	116	117	118	118	119	120	121	121	122	123	124	125	125	47
48	111	112	113	114	114	115	116	117	118	118	119	120	121	122	122	123	124	125	126	126	127	128	48
49	114	114	115	116	117	118	118	119	120	121	122	123	123	124	125	126	127	127	128	129	130	131	49
50	116	117	118	118	119	120	121	122	123	123	124	125	126	127	128	128	129	130	131	132	133	133	50
51	118	119	120	121	122	122	123	124	125	126	127	128	128	129	130	131	132	133	133	134	135	136	51
52	120	121	122	123	124	125	126	127	127	128	129	130	131	132	133	133	134	135	136	137	138	139	52
53	123	124	125	125	126	127	128	129	130	131	132	133	133	134	135	136	137	138	139	140	140	141	53
54	125	126	127	128	129	130	131	131	132	133	134	135	136	137	138	139	140	140	141	142	143	144	54
55	127	128	129	130	131	132	133	134	135	136	137	138	138	139	140	141	142	143	144	145	146	147	55
56	130	131	132	133	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	147	148	149	56
57	132	133	134	135	136	137	138	139	140	141	142	143	143	144	145	146	147	148	149	150	151	152	57
58	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	58
59	137	138	139	140	141	142	143	144	145	146	147	148	148	149	150	151	152	153	154	155	156	157	59
60	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	60

Digitized by Google

TABLE XXXI.

For finding the Sun's Right Ascension for any given number of hours.

	Number of hours.												
Horary Variation.	1	2	3	4	5	6	7	8	9	10	11	12	Horary Variation.
s	″	″	″	″	″	″	″	″	″	″	″	″	s
8.50	8.5	17.0	25.5	34.0	42.5	51.0	59.5	68.0	76.5	85.0	93.5	102.0	8.50
8.55	8.6	17.1	25.7	34.2	42.8	51.3	59.9	68.4	77.0	85.5	94.1	102.6	8.55
8.60	8.6	17.2	25.8	34.4	43.0	51.6	60.2	68.8	77.4	86.0	94.6	103.2	8.60
8.65	8.7	17.3	26.0	34.6	43.3	51.9	60.6	69.2	77.9	86.5	95.2	103.8	8.65
8.70	8.7	17.4	26.1	34.8	43.5	52.2	60.9	69.6	78.3	87.0	95.7	104.4	8.70
8.75	8.8	17.5	26.3	35.0	43.8	52.5	61.3	70.0	78.8	87.5	96.3	105.0	8.75
8.80	8.8	17.6	26.4	35.2	44.0	52.8	61.6	70.4	79.2	88.0	96.8	105.6	8.80
8.85	8.9	17.7	26.6	35.4	44.3	53.1	62.0	70.8	79.7	88.5	97.4	106.2	8.85
8.90	8.9	17.8	26.7	35.6	44.5	53.4	62.3	71.2	80.1	89.0	97.9	106.8	8.90
8.95	9.0	17.9	26.9	35.8	44.8	53.7	62.7	71.6	80.6	89.5	98.5	107.4	8.95
9.00	9.0	18.0	27.0	36.0	45.0	54.0	63.0	72.0	81.0	90.0	99.0	108.0	9.00
9.05	9.1	18.1	27.2	36.2	45.3	54.3	63.4	72.4	81.5	90.5	99.6	108.6	9.05
9.10	9.1	18.2	27.3	36.4	45.5	54.6	63.7	72.8	81.9	91.0	100.1	109.2	9.10
9.15	9.2	18.3	27.5	36.6	45.8	54.9	64.1	73.2	82.4	91.5	100.7	109.8	9.15
9.20	9.2	18.4	27.6	36.8	46.0	55.2	64.4	73.6	82.8	92.0	101.2	110.4	9.20
9.25	9.3	18.5	27.8	37.0	46.3	55.5	64.8	74.0	83.3	92.5	101.8	111.0	9.25
9.30	9.3	18.6	27.9	37.2	46.5	55.8	65.1	74.4	83.7	93.0	102.3	111.6	9.30
9.35	9.4	18.7	28.1	37.4	46.8	56.1	65.5	74.8	84.2	93.5	102.9	112.2	9.35
9.40	9.4	18.8	28.2	37.6	47.0	56.4	65.8	75.2	84.6	94.0	103.4	112.8	9.40
9.45	9.5	18.9	28.4	37.8	47.3	56.7	66.2	75.6	85.1	94.5	104.0	113.4	9.45
9.50	9.5	19.0	28.5	38.0	47.5	57.0	66.5	76.0	85.5	95.0	104.5	114.0	9.50
9.55	9.6	19.1	28.7	38.2	47.8	57.3	66.9	76.4	86.0	95.5	105.1	114.6	9.55
9.60	9.6	19.2	28.8	38.4	48.0	57.6	67.2	76.8	86.4	96.0	105.6	115.2	9.60
9.65	9.7	19.3	29.0	38.6	48.3	57.9	67.6	77.2	86.9	96.5	106.2	115.8	9.65
9.70	9.7	19.4	29.1	38.8	48.5	58.2	67.9	77.6	87.3	97.0	106.7	116.4	9.70
9.75	9.8	19.5	29.3	39.0	48.8	58.5	68.3	78.0	87.8	97.5	107.3	117.0	9.75
9.80	9.8	19.6	29.4	39.2	49.0	58.8	68.6	78.4	88.2	98.0	107.8	117.6	9.80
9.85	9.9	19.7	29.6	39.4	49.3	59.1	69.0	78.8	88.7	98.5	108.4	118.2	9.85
9.90	9.9	19.8	29.7	39.6	49.5	59.4	69.3	79.2	89.1	99.0	108.9	118.8	9.90
9.95	10.0	19.9	29.9	39.8	49.8	59.7	69.7	79.6	89.6	99.5	109.5	119.4	9.95
10.00	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	10.00
10.05	10.1	20.1	30.2	40.2	50.3	60.3	70.4	80.4	90.5	100.5	110.6	120.6	10.05
10.10	10.1	20.2	30.3	40.4	50.5	60.6	70.7	80.8	90.9	101.0	111.1	121.2	10.10
10.15	10.2	20.3	30.5	40.6	50.8	60.9	71.1	81.2	91.4	101.5	111.7	121.8	10.15
10.20	10.2	20.4	30.6	40.8	51.0	61.2	71.4	81.6	91.8	102.0	112.2	122.4	10.20
10.25	10.3	20.5	30.8	41.0	51.3	61.5	71.8	82.0	92.3	102.5	112.8	123.0	10.25
10.30	10.3	20.6	30.9	41.2	51.5	61.8	72.1	82.4	92.7	103.0	113.3	123.6	10.30
10.35	10.4	20.7	31.1	41.4	51.8	62.1	72.5	82.8	93.2	103.5	113.9	124.2	10.35
10.40	10.4	20.8	31.2	41.6	52.0	62.4	72.8	83.2	93.6	104.0	114.4	124.8	10.40
10.45	10.5	20.9	31.4	41.8	52.3	62.7	73.2	83.6	94.1	104.5	115.0	125.4	10.45
10.50	10.5	21.0	31.5	42.0	52.5	63.0	73.5	84.0	94.5	105.0	115.5	126.0	10.50
10.55	10.6	21.1	31.7	42.2	52.8	63.3	73.9	84.4	95.0	105.5	116.1	126.6	10.55
10.60	10.6	21.2	31.8	42.4	53.0	63.6	74.2	84.8	95.4	106.0	116.6	127.2	10.60
10.65	10.7	21.3	32.0	42.6	53.3	63.9	74.6	85.2	95.9	106.5	117.2	127.8	10.65
10.70	10.7	21.4	32.1	42.8	53.5	64.2	74.9	85.6	96.3	107.0	117.7	128.4	10.70
10.75	10.8	21.5	32.3	43.0	53.8	64.5	75.3	86.0	96.8	107.5	118.3	129.0	10.75
10.80	10.8	21.6	32.4	43.2	54.0	64.8	75.6	86.4	97.2	108.0	118.8	129.6	10.80
10.85	10.9	21.7	32.6	43.4	54.3	65.1	76.0	86.8	97.7	108.5	119.4	130.2	10.85
10.90	10.9	21.8	32.7	43.6	54.5	65.4	76.3	87.2	98.1	109.0	119.9	130.8	10.90
10.95	11.0	21.9	32.9	43.8	54.8	65.7	76.7	87.6	98.6	109.5	120.5	131.4	10.95
11.00	11.0	22.0	33.0	44.0	55.0	66.0	77.0	88.0	99.0	110.0	121.0	132.0	11.00
11.05	11.1	22.1	33.2	44.2	55.3	66.3	77.4	88.4	99.5	110.5	121.6	132.6	11.05
11.10	11.1	22.2	33.3	44.4	55.5	66.6	77.7	88.8	99.9	111.0	122.1	133.2	11.10
11.15	11.2	22.3	33.5	44.6	55.8	66.9	78.1	89.2	100.4	111.5	122.7	133.8	11.15
11.20	11.2	22.4	33.6	44.8	56.0	67.2	78.4	89.6	100.8	112.0	123.2	134.4	11.20
11.25	11.3	22.5	33.8	45.0	56.3	67.5	78.8	90.0	101.3	112.5	123.8	135.0	11.25
11.30	11.3	22.6	33.9	45.2	56.5	67.8	79.1	90.4	101.7	113.0	124.3	135.6	11.30
11.35	11.4	22.7	34.1	45.4	56.8	68.1	79.5	90.8	102.2	113.5	124.9	136.2	11.35
11.40	11.4	22.8	34.2	45.6	57.0	68.4	79.8	91.2	102.6	114.0	125.4	136.8	11.40
11.45	11.5	22.9	34.4	45.8	57.3	68.7	80.2	91.6	103.1	114.5	126.0	137.4	11.45

Digitized by Google

TABLE XXXI.

For finding the Sun's Right Ascension for any given number of hours.

Number of hours.

Horary Variation.	13	14	15	16	17	18	19	20	21	22	23	24	Horary Variation.
s	″	″	″	″	″	′	″	″	″	″	″	″	s
8.50	110.5	119.0	127.5	136.0	144.5	153.0	161.5	170.0	178.5	187.0	195.5	204.0	8.50
8.55	111.2	119.7	128.3	136.8	145.4	153.9	162.5	171.0	179.6	188.1	196.7	205.2	8.55
8.60	111.8	120.4	129.0	137.6	146.2	154.8	163.4	172.0	180.6	189.2	197.8	206.4	8.60
8.65	112.5	121.1	129.8	138.4	147.1	155.7	164.4	173.0	181.7	190.3	199.0	207.6	8.65
8.70	113.1	121.8	130.5	139.2	147.9	156.6	165.3	174.0	182.7	191.4	200.1	208.8	8.70
8.75	113.8	122.5	131.3	140.0	148.8	157.5	166.3	175.0	183.8	192.5	201.3	210.0	8.75
8.80	114.4	123.2	132.0	140.8	149.6	158.4	167.2	176.0	184.8	193.6	202.4	211.2	8.80
8.85	115.1	123.9	132.8	141.6	150.5	159.3	168.2	177.0	185.9	194.7	203.6	212.4	8.85
8.90	115.7	124.6	133.5	142.4	151.3	160.2	169.1	178.0	186.9	195.8	204.7	213.6	8.90
8.95	116.4	125.3	134.3	143.2	152.2	161.1	170.1	179.0	188.0	196.9	205.9	214.8	8.95
9.00	117.0	126.0	135.0	144.0	153.0	162.0	171.0	180.0	189.0	198.0	207.0	216.0	9.00
9.05	117.7	126.7	135.8	144.8	153.9	162.9	172.0	181.0	190.1	199.1	208.2	217.2	9.05
9.10	118.3	127.4	136.5	145.6	154.7	163.8	172.9	182.0	191.1	200.2	209.3	218.4	9.10
9.15	119.0	128.1	137.3	146.4	155.6	164.7	173.9	183.0	192.2	201.3	210.5	219.6	9.15
9.20	119.6	128.8	138.0	147.2	156.4	165.6	174.8	184.0	193.2	202.4	211.6	220.8	9.20
9.25	120.3	129.5	138.8	148.0	157.3	166.5	175.8	185.0	194.3	203.5	212.8	222.0	9.25
9.30	120.9	130.2	139.5	148.8	158.1	167.4	176.7	186.0	195.3	204.6	213.9	223.2	9.30
9.35	121.6	130.9	140.3	149.6	159.0	168.3	177.7	187.0	196.4	205.7	215.1	224.4	9.35
9.40	122.2	131.6	141.0	150.4	159.8	169.2	178.6	188.0	197.4	206.8	216.2	225.6	9.40
9.45	122.9	132.3	141.8	151.2	160.7	170.1	179.6	189.0	198.5	207.9	217.4	226.8	9.45
9.50	123.5	133.0	142.5	152.0	161.5	171.0	180.5	190.0	199.5	209.0	218.5	228.0	9.50
9.55	124.2	133.7	143.3	152.8	162.4	171.9	181.5	191.0	200.6	210.1	219.7	229.2	9.55
9.60	124.8	134.4	144.0	153.6	163.2	172.8	182.4	192.0	201.6	211.2	220.8	230.4	9.60
9.65	125.5	135.1	144.8	154.4	164.1	173.7	183.4	193.0	202.7	212.3	222.0	231.6	9.65
9.70	126.1	135.8	145.5	155.2	164.9	174.6	184.3	194.0	203.7	213.4	223.1	232.8	9.70
9.75	126.8	136.5	146.3	156.0	165.8	175.5	185.3	195.0	204.8	214.5	224.3	234.0	9.75
9.80	127.4	137.2	147.0	156.8	166.6	176.4	186.2	196.0	205.8	215.6	225.4	235.2	9.80
9.85	128.1	137.9	147.8	157.6	167.5	177.3	187.2	197.0	206.9	216.7	226.6	236.4	9.85
9.90	128.7	138.6	148.5	158.4	168.3	178.2	188.1	198.0	207.9	217.8	227.7	237.6	9.90
9.95	129.4	139.3	149.3	159.2	169.2	179.1	189.1	199.0	209.0	218.9	228.9	238.8	9.95
10.00	130.0	140.0	150.0	160.0	170.0	180.0	190.0	200.0	210.0	220.0	230.0	240.0	10.00
10.05	130.7	140.7	150.8	160.8	170.9	180.9	191.0	201.0	211.1	221.1	231.2	241.2	10.05
10.10	131.3	141.4	151.5	161.6	171.7	181.8	191.9	202.0	212.1	222.2	232.3	242.4	10.10
10.15	132.0	142.1	152.3	162.4	172.6	182.7	192.9	203.0	213.2	223.3	233.5	243.6	10.15
10.20	132.6	142.8	153.0	163.2	173.4	183.6	193.8	204.0	214.2	224.4	234.6	244.8	10.20
10.25	133.3	143.5	153.8	164.0	174.3	184.5	194.8	205.0	215.3	225.5	235.8	246.0	10.25
10.30	133.9	144.2	154.5	164.8	175.1	185.4	195.7	206.0	216.3	226.6	236.9	247.2	10.30
10.35	134.6	144.9	155.3	165.6	176.0	186.3	196.7	207.0	217.4	227.7	238.1	248.4	10.35
10.40	135.2	145.6	156.0	166.4	176.8	187.2	197.6	208.0	218.4	228.8	239.2	249.6	10.40
10.45	135.9	146.3	156.8	167.2	177.7	188.1	198.6	209.0	219.5	229.9	240.4	250.8	10.45
10.50	136.5	147.0	157.5	168.0	178.5	189.0	199.5	210.0	220.5	231.0	241.5	252.0	10.50
10.55	137.2	147.7	158.3	168.8	179.4	189.9	200.5	211.0	221.6	232.1	242.7	253.2	10.55
10.60	137.8	148.4	159.0	169.6	180.2	190.8	201.4	212.0	222.6	233.2	243.8	254.4	10.60
10.65	138.5	149.1	159.8	170.4	181.1	191.7	202.4	213.0	223.7	234.3	245.0	255.6	10.65
10.70	139.1	149.8	160.5	171.2	181.9	192.6	203.3	214.0	224.7	235.4	246.1	256.8	10.70
10.75	139.8	150.5	161.3	172.0	182.8	193.5	204.3	215.0	225.8	236.5	247.3	258.0	10.75
10.80	140.4	151.2	162.0	172.8	183.6	194.4	205.2	216.0	226.8	237.6	248.4	259.2	10.80
10.85	141.1	151.9	162.8	173.6	184.5	195.3	206.2	217.0	227.9	238.7	249.6	260.4	10.85
10.90	141.7	152.6	163.5	174.4	185.3	196.2	207.1	218.0	228.9	239.8	250.7	261.6	10.90
10.95	142.4	153.3	164.3	175.2	186.2	197.1	208.1	219.0	230.0	240.9	251.9	262.8	10.95
11.00	143.0	154.0	165.0	176.0	187.0	198.0	209.0	220.0	231.0	242.0	253.0	264.0	11.00
11.05	143.7	154.7	165.8	176.8	187.9	198.9	210.0	221.0	232.1	243.1	254.2	265.2	11.05
11.10	144.3	155.4	166.5	177.6	188.7	199.8	210.9	222.0	233.1	244.2	255.3	266.4	11.10
11.15	145.0	156.1	167.3	178.4	189.6	200.7	211.9	223.0	234.2	245.3	256.5	267.6	11.15
11.20	145.6	156.8	168.0	179.2	190.4	201.6	212.8	224.0	235.2	246.4	257.6	268.8	11.20
11.25	146.3	157.5	168.8	180.0	191.3	202.5	213.8	225.0	236.3	247.5	258.8	270.0	11.25
11.30	146.9	158.2	169.5	180.8	192.1	203.4	214.7	226.0	237.3	248.6	259.9	271.2	11.30
11.35	147.6	158.9	170.3	181.6	193.0	204.3	215.7	227.0	238.4	249.7	261.1	272.4	11.35
11.40	148.2	159.6	171.0	182.4	193.8	205.2	216.6	228.0	239.4	250.8	262.2	273.6	11.40
11.45	148.9	160.3	171.8	183.2	194.7	206.1	217.6	229.0	240.5	251.9	263.4	274.8	11.45

Digitized by Google

TABLE XXXII.

Variation of the Sun's Altitude in one minute from noon.

Declination of a different name from the Latitude.

Lat.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	Lat
	″	″	″	″	″	″	″	″	″	″	″	″	
0°					28.1	22.4	18.7	16.0	14.0	12.4	11.1	10.1	0°
1				28.1	22.4	18.7	16.0	14.0	12.4	11.2	10.1	9.3	1
2			28.1	22.4	18.7	16.0	14.0	12.5	11.2	10.2	9.3	8.6	2
3		28.1	22.4	18.7	16.0	14.0	12.5	11.2	10.2	9.3	8.6	8.0	3
4	28.1	22.4	18.7	16.0	14.0	12.5	11.2	10.2	9.3	8.6	8.0	7.4	4
5	22.4	18.7	16.0	14.0	12.5	11.2	10.2	9.3	8.6	8.0	7.4	7.0	5
6	18.7	16.0	14.0	12.5	11.2	10.2	9.3	8.6	8.0	7.5	7.0	6.6	6
7	16.0	14.0	12.4	11.2	10.2	9.3	8.6	8.0	7.5	7.0	6.6	6.2	7
8	14.0	12.4	11.2	10.2	9.3	8.6	8.0	7.5	7.0	6.6	6.2	5.9	8
9	12.4	11.2	10.2	9.3	8.6	8.0	7.5	7.0	6.6	6.2	5.9	5.6	9
10	11.1	10.1	9.3	8.6	8.0	7.4	7.0	6.6	6.2	5.9	5.6	5.3	10
11	10.1	9.3	8.6	8.0	7.4	7.0	6.6	6.2	5.9	5.6	5.3	5.1	11
12	9.2	8.5	7.9	7.4	7.0	6.5	6.2	5.9	5.6	5.3	5.0	4.8	12
13	8.5	7.9	7.4	6.9	6.5	6.2	5.8	5.6	5.3	5.0	4.8	4.6	13
14	7.9	7.4	6.9	6.5	6.2	5.8	5.5	5.3	5.0	4.8	4.6	4.4	14
15	7.3	6.9	6.5	6.1	5.8	5.5	5.3	5.0	4.8	4.6	4.4	4.2	15
16	6.8	6.5	6.1	5.8	5.5	5.2	5.0	4.8	4.6	4.4	4.2	4.1	16
17	6.4	6.1	5.8	5.5	5.2	5.0	4.8	4.6	4.4	4.2	4.1	3.9	17
18	6.0	5.7	5.5	5.2	5.0	4.8	4.6	4.4	4.2	4.1	3.9	3.8	18
19	5.7	5.4	5.2	4.9	4.7	4.5	4.4	4.2	4.0	3.9	3.8	3.6	19
20	5.4	5.1	4.9	4.7	4.5	4.3	4.2	4.0	3.9	3.8	3.6	3.5	20
21	5.1	4.9	4.7	4.5	4.3	4.2	4.0	3.9	3.7	3.6	3.5	3.4	21
22	4.9	4.7	4.5	4.3	4.1	4.0	3.9	3.7	3.6	3.5	3.4	3.3	22
23	4.6	4.4	4.3	4.1	4.0	3.8	3.7	3.6	3.5	3.4	3.3	3.2	23
24	4.4	4.2	4.1	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.2	3.1	24
25	4.2	4.1	3.9	3.8	3.7	3.5	3.4	3.3	3.2	3.1	3.1	3.0	25
26	4.0	3.9	3.8	3.6	3.5	3.4	3.3	3.2	3.1	3.0	3.0	2.9	26
27	3.9	3.7	3.6	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.9	2.8	27
28	3.7	3.6	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.8	2.7	28
29	3.5	3.4	3.3	3.2	3.1	3.1	3.0	2.9	2.8	2.8	2.7	2.6	29
30	3.4	3.3	3.2	3.1	3.0	3.0	2.9	2.8	2.7	2.7	2.6	2.5	30
31	3.3	3.2	3.1	3.0	2.9	2.9	2.8	2.7	2.6	2.6	2.5	2.5	31
32	3.1	3.1	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5	2.5	2.4	32
33	3.0	2.9	2.9	2.8	2.7	2.7	2.6	2.5	2.5	2.4	2.4	2.3	33
34	2.9	2.8	2.8	2.7	2.6	2.6	2.5	2.5	2.4	2.4	2.3	2.3	34
35	2.8	2.7	2.7	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.2	2.2	35
36	2.7	2.6	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.1	36
37	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.2	2.1	2.1	37
38	2.5	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.1	2.0	38
39	2.4	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.1	2.0	2.0	2.0	39
40	2.3	2.3	2.2	2.2	2.2	2.1	2.1	2.0	2.0	2.0	1.9	1.9	40
41	2.3	2.2	2.2	2.1	2.1	2.1	2.0	2.0	1.9	1.9	1.9	1.8	41
42	2.2	2.1	2.1	2.1	2.0	2.0	2.0	1.9	1.9	1.9	1.8	1.8	42
43	2.1	2.1	2.0	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.8	1.7	43
44	2.0	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7	44
45	2.0	1.9	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.6	45
46	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.6	1.6	1.6	46
47	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.6	47
48	1.8	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.5	1.5	48
49	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	49
50	1.6	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.4	1.4	50
52	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.3	52
54	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	54
56	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	56
58	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	58
60	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	60
62	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	62
64	1.0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	64
66	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	66
68	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	68
70	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	70
	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	

Digitized by Google

TABLE XXXII.

Variation of the Sun's Altitude in one minute from noon.

Lat.	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	Lat.
	Declination of a different name from the Latitude.													
	"	"	"	"	"	"	"	"	"	"	"	"	"	
0°	9.2	8.5	7.9	7.3	6.8	6.4	6.0	5.7	5.4	5.1	4.9	4.6	4.4	0°
1	8.5	7.9	7.4	6.9	6.5	6.1	5.7	5.4	5.1	4.9	4.7	4.4	4.2	1
2	7.9	7.4	6.9	6.5	6.1	5.8	5.5	5.2	4.9	4.7	4.5	4.3	4.1	2
3	7.4	6.9	6.5	6.1	5.8	5.5	5.2	4.9	4.7	4.5	4.3	4.1	3.9	3
4	7.0	6.5	6.2	5.8	5.5	5.2	5.0	4.7	4.5	4.3	4.1	4.0	3.8	4
5	6.5	6.2	5.8	5.5	5.2	5.0	4.8	4.5	4.3	4.2	4.0	3.8	3.7	5
6	6.2	5.8	5.5	5.3	5.0	4.8	4.6	4.4	4.2	4.0	3.9	3.7	3.6	6
7	5.9	5.6	5.3	5.0	4.8	4.6	4.4	4.2	4.0	3.9	3.7	3.6	3.5	7
8	5.6	5.3	5.0	4.8	4.6	4.4	4.2	4.0	3.9	3.7	3.6	3.5	3.4	8
9	5.3	5.0	4.8	4.6	4.4	4.2	4.1	3.9	3.8	3.6	3.5	3.4	3.3	9
10	5.0	4.8	4.6	4.4	4.2	4.1	3.9	3.8	3.6	3.5	3.4	3.3	3.2	10
11	4.8	4.6	4.4	4.2	4.1	3.9	3.8	3.6	3.5	3.4	3.3	3.2	3.1	11
12	4.6	4.4	4.3	4.1	3.9	3.8	3.7	3.5	3.4	3.3	3.2	3.1	3.0	12
13	4.4	4.3	4.1	3.9	3.8	3.7	3.5	3.4	3.3	3.2	3.1	3.0	2.9	13
14	4.2	4.1	3.9	3.8	3.7	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8	14
15	4.1	3.9	3.8	3.7	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.8	15
16	3.9	3.8	3.7	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.8	2.7	16
17	3.8	3.7	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.8	2.7	2.6	17
18	3.7	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.9	2.8	2.7	2.6	2.5	18
19	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.9	2.8	2.7	2.6	2.6	2.5	19
20	3.4	3.3	3.2	3.1	3.0	2.9	2.9	2.8	2.7	2.6	2.6	2.5	2.4	20
21	3.3	3.2	3.1	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5	2.4	2.4	21
22	3.2	3.1	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5	2.4	2.4	2.3	22
23	3.1	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.5	2.4	2.4	2.3	2.3	23
24	3.0	2.9	2.8	2.8	2.7	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.2	24
25	2.9	2.8	2.7	2.7	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.2	2.2	25
26	2.8	2.7	2.7	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.2	2.1	2.1	26
27	2.7	2.7	2.6	2.5	2.5	2.4	2.4	2.3	2.2	2.2	2.1	2.1	2.1	27
28	2.6	2.6	2.5	2.5	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.1	2.0	28
29	2.6	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.0	2.0	2.0	29
30	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.0	2.0	2.0	1.9	30
31	2.4	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.0	2.0	2.0	1.9	1.9	31
32	2.3	2.3	2.2	2.2	2.2	2.1	2.1	2.0	2.0	1.9	1.9	1.9	1.8	32
33	2.3	2.2	2.2	2.1	2.1	2.1	2.0	2.0	1.9	1.9	1.9	1.8	1.8	33
34	2.2	2.2	2.1	2.1	2.0	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.8	34
35	2.2	2.1	2.1	2.0	2.0	2.0	1.9	1.9	1.8	1.8	1.8	1.7	1.7	35
36	2.1	2.1	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7	36
37	2.0	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.6	37
38	2.0	1.9	1.9	1.9	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.6	1.6	38
39	1.9	1.9	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.6	1.6	1.6	1.6	39
40	1.9	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.5	40
41	1.8	1.8	1.8	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.5	1.5	1.5	41
42	1.8	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5	42
43	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.4	1.4	43
44	1.7	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.4	44
45	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.4	45
46	1.6	1.6	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.3	1.3	46
47	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3	47
48	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	48
49	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	49
50	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	50
52	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.1	1.1	52
54	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	54
56	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	56
58	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	58
60	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.9	0.9	60
62	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.8	62
64	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	64
66	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7		66
68	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7				68
70	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6						70
	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	

Digitized by Google

TABLE XXXII.

Variation of the Sun's Altitude in one minute from noon.

Lat.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	Lat.
	Declination of the same name as the Latitude.												
	"	"	"	"	"	"	"	"	"	"	"	"	
0°					28.1	22.4	18.7	16.0	14.0	12.4	11.1	10.1	0°
1						28.0	22.4	18.6	16.0	13.9	12.4	11.1	1
2							28.0	22.3	18.6	15.9	13.9	12.3	2
3								27.9	22.3	18.5	15.8	13.8	3
4	28.1								27.8	22.2	18.5	15.8	4
5	22.4	28.0								27.7	22.1	18.4	5
6	18.7	22.4	28.0								27.6	22.0	6
7	16.0	18.6	22.3	27.9								27.4	7
8	14.0	16.0	18.6	22.3	27.8								8
9	12.4	13.9	15.9	18.5	22.2	27.7							9
10	11.1	12.4	13.9	15.8	18.5	22.1	27.6						10
11	10.1	11.1	12.3	13.8	15.8	18.4	22.0	27.4					11
12	9.2	10.1	11.1	12.3	13.8	15.7	18.3	21.9	27.3				12
13	8.5	9.2	10.0	11.0	12.2	13.7	15.6	18.2	21.7	27.1			13
14	7.9	8.5	9.2	10.0	10.9	12.1	13.6	15.5	18.0	21.6	26.9		14
15	7.3	7.8	8.4	9.1	9.9	10.9	12.1	13.5	15.4	17.9	21.4	26.7	15
16	6.8	7.3	7.8	8.4	9.1	9.8	10.8	12.0	13.4	15.3	17.8	21.3	16
17	6.4	6.8	7.2	7.8	8.3	9.0	9.8	10.7	11.9	13.3	15.2	17.6	17
18	6.0	6.4	6.8	7.2	7.7	8.3	8.9	9.7	10.6	11.8	13.2	15.0	18
19	5.7	6.0	6.3	6.7	7.2	7.6	8.2	8.9	9.6	10.6	11.7	13.1	19
20	5.4	5.7	6.0	6.3	6.7	7.1	7.6	8.1	8.8	9.5	10.5	11.6	20
21	5.1	5.4	5.6	5.9	6.3	6.6	7.0	7.5	8.1	8.7	9.5	10.4	21
22	4.9	5.1	5.3	5.6	5.9	6.2	6.6	7.0	7.5	8.0	8.6	9.4	22
23	4.6	4.8	5.0	5.3	5.5	5.8	6.1	6.5	6.9	7.4	7.9	8.5	23
24	4.4	4.6	4.8	5.0	5.2	5.5	5.8	6.1	6.4	6.8	7.3	7.8	24
25	4.2	4.4	4.6	4.7	5.0	5.2	5.4	5.7	6.0	6.4	6.8	7.2	25
26	4.0	4.2	4.3	4.5	4.7	4.9	5.1	5.4	5.7	6.0	6.3	6.7	26
27	3.9	4.0	4.1	4.3	4.5	4.7	4.9	5.1	5.3	5.6	5.9	6.2	27
28	3.7	3.8	4.0	4.1	4.3	4.4	4.6	4.8	5.0	5.3	5.5	5.8	28
29	3.5	3.7	3.8	3.9	4.1	4.2	4.4	4.6	4.7	5.0	5.2	5.5	29
30	3.4	3.5	3.6	3.7	3.9	4.0	4.2	4.3	4.5	4.7	4.9	5.1	30
31	3.3	3.4	3.5	3.6	3.7	3.8	4.0	4.1	4.3	4.4	4.6	4.8	31
32	3.1	3.2	3.3	3.4	3.5	3.7	3.8	3.9	4.1	4.2	4.4	4.6	32
33	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.9	4.0	4.2	4.3	33
34	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.6	3.7	3.8	3.9	4.1	34
35	2.8	2.9	3.0	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.9	35
36	2.7	2.8	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	36
37	2.6	2.7	2.7	2.8	2.9	2.9	3.0	3.1	3.2	3.3	3.4	3.5	37
38	2.5	2.6	2.6	2.7	2.8	2.8	2.9	3.0	3.0	3.2	3.2	3.3	38
39	2.4	2.5	2.5	2.6	2.7	2.7	2.8	2.9	2.9	3.0	3.1	3.2	39
40	2.3	2.4	2.4	2.5	2.6	2.6	2.7	2.7	2.8	2.9	3.0	3.0	40
41	2.3	2.3	2.4	2.4	2.5	2.5	2.6	2.6	2.7	2.8	2.8	2.9	41
42	2.2	2.2	2.3	2.3	2.4	2.4	2.5	2.5	2.6	2.6	2.7	2.8	42
43	2.1	2.1	2.2	2.2	2.3	2.3	2.4	2.4	2.5	2.5	2.6	2.7	43
44	2.0	2.1	2.1	2.1	2.2	2.2	2.3	2.3	2.4	2.4	2.5	2.5	44
45	2.0	2.0	2.0	2.1	2.1	2.2	2.2	2.2	2.3	2.3	2.4	2.4	45
46	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.2	2.2	2.2	2.3	2.3	46
47	1.8	1.9	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.1	2.2	2.2	47
48	1.8	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.1	48
49	1.7	1.7	1.8	1.8	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.1	49
50	1.6	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.9	1.9	1.9	2.0	50
52	1.5	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.8	1.8	1.8	52
54	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.7	54
56	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5	56
58	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.4	58
60	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	60
62	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	62
64	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	64
66	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	66
68	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	68
70	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	70
	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	

Digitized by Google

TABLE XXXII.

Variation of the Sun's Altitude in one minute from noon.

	Declination of the same name as the Latitude.													
	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	
Lat.	"	"	"	"	"	"	"	"	"	"	"	"	"	Lat.
0°	9.2	8.5	7.9	7.3	6.8	6.4	6.0	5.7	5.4	5.1	4.9	4.6	4.4	0°
1	10.1	9.2	8.5	7.8	7.3	6.8	6.4	6.0	5.7	5.4	5.1	4.8	4.6	1
2	11.1	10.0	9.2	8.4	7.8	7.2	6.8	6.3	6.0	5.6	5.3	5.0	4.8	2
3	12.3	11.0	10.0	9.1	8.4	7.8	7.2	6.7	6.3	5.9	5.6	5.3	5.0	3
4	13.8	12.2	10.9	9.9	9.1	8.3	7.7	7.2	6.7	6.3	5.9	5.5	5.2	4
5	15.7	13.7	12.1	10.9	9.8	9.0	8.3	7.6	7.1	6.6	6.2	5.8	5.5	5
6	18.3	15.6	13.6	12.1	10.8	9.8	8.9	8.2	7.6	7.0	6.6	6.1	5.8	6
7	21.9	18.2	15.5	13.5	12.0	10.7	9.7	8.9	8.1	7.5	7.0	6.5	6.1	7
8	27.3	21.7	18.0	15.4	13.4	11.9	10.6	9.6	8.8	8.1	7.5	6.9	6.4	8
9		27.1	21.6	17.9	15.3	13.3	11.8	10.6	9.5	8.7	8.0	7.4	6.8	9
10			26.9	21.4	17.8	15.2	13.2	11.7	10.5	9.5	8.6	7.9	7.3	10
11				26.7	21.3	17.6	15.0	13.1	11.6	10.4	9.4	8.5	7.8	11
12					26.5	21.1	17.5	14.9	13.0	11.5	10.3	9.3	8.4	12
13						26.2	20.9	17.3	14.8	12.8	11.3	10.1	9.2	13
14							26.0	20.7	17.1	14.6	12.7	11.2	10.0	14
15								25.7	20.4	16.9	14.4	12.5	11.1	15
16	26.5								25.4	20.2	16.7	14.3	12.4	16
17	21.1	26.2								25.1	20.0	16.5	14.1	17
18	17.5	20.9	26.0								24.8	19.7	16.3	18
19	14.9	17.3	20.7	25.7								24.5	19.5	19
20	13.0	14.8	17.1	20.4	25.4								24.2	20
21	11.5	12.8	14.6	16.9	20.2	25.1								21
22	10.3	11.3	12.7	14.4	16.7	20.0	24.8							22
23	9.3	10.1	11.2	12.5	14.3	16.5	19.7	24.5						23
24	8.4	9.2	10.0	11.1	12.4	14.1	16.3	19.5	24.2					24
25	7.7	8.3	9.0	9.9	10.9	12.2	13.9	16.1	19.2	23.8				25
26	7.1	7.6	8.2	8.9	9.8	10.8	12.1	13.7	15.9	18.9	23.5			26
27	6.6	7.0	7.5	8.1	8.8	9.6	10.6	11.9	13.5	15.6	18.6	23.1		27
28	6.2	6.5	7.0	7.4	8.0	8.7	9.5	10.5	11.7	13.3	15.4	18.3	22.7	28
29	5.7	6.1	6.4	6.9	7.3	7.9	8.6	9.4	10.3	11.5	13.1	15.1	18.0	29
30	5.4	5.7	6.0	6.4	6.8	7.2	7.8	8.4	9.2	10.1	11.3	12.8	14.9	30
31	5.1	5.3	5.6	5.9	6.3	6.7	7.1	7.7	8.3	9.0	10.0	11.1	12.6	31
32	4.8	5.0	5.2	5.5	5.8	6.2	6.5	7.0	7.5	8.1	8.9	9.8	10.9	32
33	4.5	4.7	4.9	5.1	5.4	5.7	6.1	6.4	6.9	7.4	8.0	8.7	9.6	33
34	4.3	4.4	4.6	4.8	5.1	5.3	5.6	5.9	6.3	6.8	7.3	7.8	8.6	34
35	4.0	4.2	4.4	4.5	4.7	5.0	5.2	5.5	5.8	6.2	6.6	7.1	7.7	35
36	3.8	4.0	4.1	4.3	4.5	4.7	4.9	5.1	5.4	5.7	6.1	6.5	7.0	36
37	3.6	3.8	3.9	4.0	4.2	4.4	4.6	4.8	5.0	5.3	5.6	6.0	6.4	37
38	3.4	3.6	3.7	3.8	4.0	4.1	4.3	4.5	4.7	4.9	5.2	5.5	5.8	38
39	3.3	3.4	3.5	3.6	3.8	3.9	4.0	4.2	4.4	4.6	4.8	5.1	5.4	39
40	3.1	3.2	3.3	3.4	3.6	3.7	3.8	4.0	4.1	4.3	4.5	4.7	5.0	40
41	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.9	4.0	4.2	4.4	4.6	41
42	2.9	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.7	3.8	4.0	4.1	4.3	42
43	2.7	2.8	2.9	3.0	3.0	3.1	3.2	3.3	3.5	3.6	3.7	3.9	4.0	43
44	2.6	2.7	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.8	44
45	2.5	2.6	2.6	2.7	2.8	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	45
46	2.4	2.4	2.5	2.6	2.6	2.7	2.8	2.8	2.9	3.0	3.1	3.2	3.3	46
47	2.3	2.3	2.4	2.4	2.5	2.6	2.6	2.7	2.8	2.9	2.9	3.0	3.1	47
48	2.2	2.2	2.3	2.3	2.4	2.4	2.5	2.6	2.6	2.7	2.8	2.9	3.0	48
49	2.1	2.1	2.2	2.2	2.3	2.3	2.4	2.4	2.5	2.6	2.6	2.7	2.8	49
50	2.0	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.4	2.4	2.5	2.6	2.6	50
52	1.8	1.9	1.9	1.9	2.0	2.0	2.1	2.1	2.1	2.2	2.2	2.3	2.4	52
54	1.7	1.7	1.7	1.8	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.1	2.1	54
56	1.5	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.8	1.8	1.8	1.9	1.9	56
58	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.7	1.7	58
60	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5	60
62	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.4	62
64	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	64
66	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	66
68	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	68
70	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	70
	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	

Digitized by Google

TABLE XXXIII.

To reduce the numbers of Table XXXII to other given intervals of time from noon.

	Time from Noon.													
S.	0′	1′	2′	3′	4′	5′	6′	7′	8′	9′	10′	11′	12′	S.
0	0.0	1.0	4.0	9.0	16.0	25.0	36.0	49.0	64.0	81.0	100.0	121.0	144.0	0
1	0.0	1.0	4.1	9.1	16.1	25.2	36.2	49.2	64.3	81.3	100.3	121.4	144.4	1
2	0.0	1.1	4.1	9.2	16.3	25.3	36.4	49.5	64.5	81.6	100.7	121.7	144.8	2
3	0.0	1.1	4.2	9.3	16.4	25.5	36.6	49.7	64.8	81.9	101.0	122.1	145.2	3
4	0.0	1.1	4.3	9.4	16.5	25.7	36.8	49.9	65.1	82.2	101.3	122.5	145.6	4
5	0.0	1.2	4.3	9.5	16.7	25.8	37.0	50.2	65.3	82.5	101.7	122.9	146.0	5
6	0.0	1.2	4.4	9.6	16.8	26.0	37.2	50.4	65.6	82.8	102.0	123.2	146.4	6
7	0.0	1.2	4.5	9.7	16.9	26.2	37.4	50.6	65.9	83.1	102.3	123.6	146.8	7
8	0.0	1.3	4.6	9.8	17.1	26.4	37.6	50.9	66.1	83.4	102.7	124.0	147.2	8
9	0.0	1.3	4.6	9.9	17.2	26.5	37.8	51.1	66.4	83.7	103.0	124.3	147.6	9
10	0.0	1.4	4.7	10.0	17.4	26.7	38.0	51.4	66.7	84.0	103.4	124.7	148.0	10
11	0.0	1.4	4.8	10.1	17.5	26.9	38.2	51.6	67.0	84.3	103.7	125.1	148.4	11
12	0.0	1.4	4.8	10.2	17.6	27.0	38.4	51.8	67.2	84.6	104.0	125.4	148.8	12
13	0.0	1.5	4.9	10.3	17.8	27.2	38.6	52.1	67.5	84.9	104.4	125.8	149.2	13
14	0.1	1.5	5.0	10.5	17.9	27.4	38.9	52.3	67.8	85.3	104.7	126.2	149.7	14
15	0.1	1.6	5.1	10.6	18.1	27.6	39.1	52.6	68.1	85.6	105.1	126.6	150.1	15
16	0.1	1.6	5.1	10.7	18.2	27.7	39.3	52.8	68.3	85.9	105.4	126.9	150.5	16
17	0.1	1.6	5.2	10.8	18.3	27.9	39.5	53.0	68.6	86.2	105.7	127.3	150.9	17
18	0.1	1.7	5.3	10.9	18.5	28.1	39.7	53.3	68.8	86.5	106.1	127.7	151.3	18
19	0.1	1.7	5.4	11.0	18.6	28.3	39.9	53.5	69.2	86.8	106.4	128.1	151.7	19
20	0.1	1.8	5.4	11.1	18.8	28.4	40.1	53.8	69.4	87.1	106.8	128.4	152.1	20
21	0.1	1.8	5.5	11.2	18.9	28.6	40.3	54.0	69.7	87.4	107.1	128.8	152.5	21
22	0.1	1.9	5.6	11.3	19.1	28.8	40.5	54.3	70.0	87.7	107.5	129.2	152.9	22
23	0.1	1.9	5.7	11.4	19.2	29.0	40.7	54.5	70.3	88.0	107.8	129.6	153.3	23
24	0.2	2.0	5.8	11.6	19.4	29.2	41.0	54.8	70.6	88.4	108.2	130.0	153.8	24
25	0.2	2.0	5.8	11.7	19.5	29.3	41.2	55.0	70.8	88.7	108.5	130.3	154.2	25
26	0.2	2.1	5.9	11.8	19.7	29.5	41.4	55.3	71.1	89.0	108.9	130.7	154.6	26
27	0.2	2.1	6.0	11.9	19.8	29.7	41.6	55.5	71.4	89.3	109.2	131.1	155.0	27
28	0.2	2.2	6.1	12.0	20.0	29.9	41.8	55.8	71.7	89.6	109.6	131.5	155.4	28
29	0.2	2.2	6.2	12.1	20.1	30.1	42.0	56.0	72.0	89.9	109.9	131.9	155.8	29
30	0.2	2.2	6.2	12.2	20.2	30.2	42.2	56.2	72.2	90.2	110.2	132.2	156.2	30
31	0.3	2.3	6.3	12.4	20.4	30.4	42.5	56.5	72.5	90.6	110.6	132.6	156.7	31
32	0.3	2.4	6.4	12.5	20.6	30.6	42.7	56.8	72.8	90.9	111.0	133.0	157.1	32
33	0.3	2.4	6.5	12.6	20.7	30.8	42.9	57.0	73.1	91.2	111.3	133.4	157.5	33
34	0.3	2.5	6.6	12.7	20.9	31.0	43.1	57.3	73.4	91.5	111.7	133.8	157.9	34
35	0.3	2.5	6.7	12.8	21.0	31.2	43.3	57.5	73.7	91.8	112.0	134.2	158.3	35
36	0.4	2.6	6.8	13.0	21.2	31.4	43.6	57.8	74.0	92.2	112.4	134.6	158.8	36
37	0.4	2.6	6.8	13.1	21.3	31.5	43.8	58.0	74.3	92.5	112.7	134.9	159.2	37
38	0.4	2.7	6.9	13.2	21.5	31.7	44.0	58.3	74.5	92.8	113.1	135.3	159.6	38
39	0.4	2.7	7.0	13.3	21.6	31.9	44.2	58.5	74.8	93.1	113.4	135.7	160.0	39
40	0.4	2.8	7.1	13.4	21.8	32.1	44.4	58.8	75.1	93.4	113.8	136.1	160.4	40
41	0.5	2.8	7.2	13.6	21.9	32.3	44.7	59.0	75.4	93.8	114.1	136.5	160.9	41
42	0.5	2.9	7.3	13.7	22.1	32.5	44.9	59.3	75.7	94.1	114.5	136.9	161.3	42
43	0.5	2.9	7.4	13.8	22.2	32.7	45.1	59.5	76.0	94.4	114.8	137.3	161.7	43
44	0.5	3.0	7.5	13.9	22.4	32.9	45.3	59.8	76.3	94.7	115.2	137.7	162.1	44
45	0.6	3.1	7.6	14.1	22.6	33.1	45.6	60.1	76.6	95.1	115.6	138.1	162.6	45
46	0.6	3.1	7.7	14.2	22.7	33.3	45.8	60.3	76.9	95.4	115.9	138.5	163.0	46
47	0.6	3.2	7.7	14.3	22.9	33.4	46.0	60.6	77.1	95.7	116.3	138.8	163.4	47
48	0.6	3.2	7.8	14.4	23.0	33.6	46.2	60.8	77.4	96.0	116.6	139.2	163.8	48
49	0.7	3.3	7.9	14.6	23.2	33.8	46.5	61.1	77.7	96.4	117.0	139.6	164.3	49
50	0.7	3.4	8.0	14.7	23.4	34.0	46.7	61.4	78.0	96.7	117.4	140.0	164.7	50
51	0.7	3.4	8.1	14.8	23.5	34.2	46.9	61.6	78.3	97.0	117.7	140.4	165.1	51
52	0.8	3.5	8.2	15.0	23.7	34.4	47.2	61.9	78.6	97.4	118.1	140.8	165.6	52
53	0.8	3.5	8.3	15.1	23.8	34.6	47.4	62.1	78.9	97.7	118.4	141.2	166.0	53
54	0.8	3.6	8.4	15.2	24.0	34.8	47.6	62.4	79.2	98.0	118.8	141.6	166.4	54
55	0.8	3.7	8.5	15.3	24.2	35.0	47.8	62.7	79.5	98.3	119.2	142.0	166.8	55
56	0.9	3.7	8.6	15.5	24.3	35.2	48.1	62.9	79.8	98.7	119.5	142.4	167.3	56
57	0.9	3.8	8.7	15.6	24.5	35.4	48.3	63.2	80.1	99.0	119.9	142.8	167.7	57
58	0.9	3.9	8.8	15.7	24.7	35.6	48.5	63.5	80.4	99.3	120.3	143.2	168.1	58
59	1.0	3.9	8.9	15.9	24.8	35.8	48.8	63.7	80.7	99.7	120.6	143.6	168.6	59
	0′	1′	2′	3′	4′	5′	6′	7′	8′	9′	10	11′	12′	

Digitized by Google

TABLES XXXIV., XXXV., AND XXXVI.

TABLE XXXIV.

Errors arising from a deviation of 1′ in the parallelism of the surfaces of the central mirror.

Obs'd. Angle	Obs. to right.	Obs. to left.	Obs. cross.	Fifth col.
D.	′ ″	′ ″	′ ″	′ ″
0	0	0	0	0
10	2	1	2	0
20	5	2	4	2
30	10	1	6	4
40	16	0	8	7
45	19	1	9	9
50	23	2	11	11
55	28	4	12	14
60	33	5	14	17
65	39	7	16	21
70	46	10	18	25
75	54	12	21	30
80	1. 4	16	24	35
85	1.15	19	28	41
90	1.27	23	32	48
95	1.43	28	37	56
100	2. 1	33	44	1. 6
105	2.23	39	52	1.16
110	2.49	46	1. 1	1.29
115	3.23	54	1.14	1.44
120	4.05	1. 4	1.30	2. 3
130				2.51
140				4. 6

TABLE XXXV.

Angles Obs'd.	Angle of deviation.										
	10′	15′	20′	25′	30′	35′	40′	45′	50′	55	60′
D.	″	″	″	″	″	″	″	″	″	″	″
0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	1	1	1	2	2	3	4	5	5
20	0	1	1	2	3	4	5	6	8	9	11
30	0	1	2	3	4	6	7	9	12	14	17
40	1	1	3	4	6	8	10	13	16	19	23
50	1	2	3	5	7	10	13	16	20	25	29
60	1	2	4	6	9	12	16	20	25	30	36
65	1	3	4	7	10	14	18	23	28	34	40
70	1	3	5	8	11	15	20	25	31	37	44
75	1	3	5	8	12	16	21	27	33	41	48
80	1	3	6	9	13	18	23	30	37	44	53
85	2	4	6	10	14	20	26	32	40	48	58
90	2	4	7	11	16	21	28	35	44	53	63
95	2	4	8	12	17	23	30	39	48	58	69
100	2	5	8	13	19	25	33	42	52	63	75
105	2	5	9	14	20	28	36	46	57	69	82
110	2	6	10	16	22	31	40	50	62	75	90
115	3	6	11	17	25	34	44	55	68	83	99
120	3	7	12	19	27	37	48	61	76	91	109

TABLE XXXVI.

Corrections of the mean refraction for various heights of the Thermometer and Barometer.

Ht. Th.	20°	24°	28°	32°	36°	40°	44°	48°	52°	56°	60°	64°	68°	72°	76°
Barom.	32.00	31.66	31.32	30.99	30.67	30.36	30.05	29.75	29.45	29.16	28.88	28.60	28.33	28.06	27.80
app. alt.	′+″	′+″	′+″	′+″	′+″	′+″	′+″	′+″	′−″	′−″	′−″	′−″	′−″	′−″	′−″
° ′															
0 0	2 41	2 18	1 55	1 33	1 12	0 51	0 30	0 10	0 10	0 29	0 48	1 7	1 25	1 43	2 1
0 30	2 18	1 58	1 39	1 20	1 2	44	26	9	8	25	41	58	1 13	1 29	1 44
1 0	1 59	1 42	1 26	1 9	53	38	22	7	7	22	36	50	1 3	1 17	1 30
1 30	1 43	1 29	1 14	1 0	46	33	19	6	6	19	31	43	55	1 6	1 18
2 0	1 30	1 18	1 5	0 53	40	29	17	6	6	16	27	37	48	58	1 8
2 30	1 20	1 8	57	46	36	25	15	5	5	15	24	33	43	51	1 0
3 0	1 11	1 1	51	41	32	22	13	4	4	13	21	30	38	46	53
4	58	49	41	33	26	18	11	4	4	10	17	24	31	37	43
5	48	41	35	28	22	15	9	3	3	9	14	20	26	31	36
6	41	35	30	24	18	13	8	3	3	7	12	17	22	26	31
7	36	31	26	21	16	11	7	2	2	7	11	15	19	23	27
8	32	27	23	18	14	10	6	2	2	6	10	13	17	20	24
9	28	24	20	16	13	9	5	2	2	5	9	12	15	18	21
10	26	22	18	15	11	8	5	2	2	5	8	10	14	16	19
12	21	18	15	12	10	7	4	1	1	4	6	9	11	14	16
14	18	16	13	11	8	6	3	1	1	3	6	8	10	12	14
16	16	14	11	9	7	5	3	1	1	3	5	7	9	10	12
18	14	12	10	8	6	4	3	1	1	3	4	6	7	9	11
21	12	10	9	7	5	4	2	1	1	2	4	5	6	8	9
24	10	9	7	6	5	3	2	1	1	2	3	4	5	7	8
27	9	8	6	5	4	3	2	1	1	2	3	4	5	6	7
30	8	7	6	5	4	3	1	0	0	1	2	3	4	5	6
35	7	6	5	4	3	2	1	0	0	1	2	3	3	4	5
40	6	5	4	3	2	2	1	0	0	1	2	2	3	4	4
45	5	4	3	3	2	1	1	0	0	1	1	2	2	3	3
50	4	3	3	2	2	1	1	0	0	1	1	2	2	3	3
60	3	2	2	2	1	1	1	0	0	0	1	1	1	2	2
70	2	1	1	1	1	1	0	0	0	0	1	1	1	1	1
80	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Digitized by Google

TABLE XXXVII.

Longitudes and Latitudes of Stars, for Jan. 1830.

Names of STARS.		Mag.	Longitude.	Ann.Var. aft. 1830.	Latitude.	Ann.Var. aft. 1830.
			s ° ′ ″	″	° ′ ″	′
γ Pegasi	*Algenib*	2	0. 6.47.09	50.09	12.35.43 N	+0.12
α Andromedæ	*Alpheratz*	2	0.11.56.26	49.98	25.41. 9 N	+0.16
η Piscium		4.3	0.24.26.32	50.16	5.22. 5 N.	+0.25
α Arietis		2.3	1. 5.17.07	50.27	9.57.40 N.	+0.16
α Ceti	*Menkar*	2	1.11.56.41	50.27	12.35.40 S.	—0.37
η Pleiadum	*Alcyone*	3	1.27.36.57	50.18	4. 2. 7 N.	+0.43
γ Tauri		3	2. 3.25.14	50.21	5.44.56 S.	—0.45
ε Tauri		3.4	2. 6. 4.55	50.20	2.35. 1 S.	—0.46
α Tauri	Aldebaran	1	2. 7.24.45	50.21	5.28.41 S.	—0.33
β Orionis	*Rigel*	1	2.14.27. 7	50.24	31. 8.39 S.	—0.47
α Aurigæ	*Capella*	1	2.19.28.47	50.19	22.52.17 N.	+0.48
δ Orionis		2	2.19.59.17	50.20	23.34.29 S.	—0.48
β Tauri		2	2.20.11.58	50.20	5.22.31 N.	+0.48
ε Orionis		2	2.21. 5.23	50.20	24.31.38 S.	—0.48
ζ Orionis		2	2.22.18.26	50.20	25.18.51 S.	—0.48
ζ Tauri		3	2.22.24.32	50.20	2.12.55 S.	—0.48
α Orionis	*Betergueze*	1	2.26.22.42	50.19	16. 2.59 S.	—0.48
η Geminorum		3.4	3. 1. 3.54	50.20	0.54.28 S.	—0.48
μ Geminorum		3	3. 2.55.14	50.20	0.49.59 S.	—0.47
γ Geminorum		2.3	3. 6.43.35	50.18	6.45.36 S.	—0.47
ε Geminorum		3	3. 7.33.46	50.20	2. 3.00 N.	+0.46
α Canis Majoris	*Sirius*	1	3.11.44.55	50.07	39.22.26 S.	—0.45
ζ Geminorum		3.4	3.12.36.52	50.19	2. 3.31 S.	—0.45
δ Geminorum		3	3.16. 8.43	50.20	0.11.50 S.	—0.44
α Geminorum	*Castor*	1.2	3.17.52.24	50.23	10. 5. 4 N.	+0.43
β Geminorum	Pollux	2	3.20.52.06	49.50	6.40.20 N.	+0.26
α Canis Minoris	*Procyon*	1.2	3.23.27.09	50.12	15.57.43 S.	—0.41
α 2 Cancri	*Acubens*	4.3	4.11.15.52	50.16	5. 5.35 S.	—0.31
α Hydræ	*Alphard*	2	4.24.54.50	50.02	22.23.36 S.	—0.22
η Leonis		3.4	4.25.31.40	50.23	4.51.21 N.	+0.22
α Leonis	Regulus	1	4.27.27.53	49.94	0.27.41 N.	+0.22
β Leonis	*Denebola*	1.2	5.19.15.54	50.30	12.17.10 N.	+0.03
β Virginis		3	5.24.44.16	50.20	0.41.32 N.	—0.02
η Virginis		4.3	6. 2.27.42	50.21	1.22.22 N.	—0.08
γ Virginis		3	6. 7.48.04	50.00	2.48.42 N.	—0.13
α Virginis	Spica	1	6.21.28.05	50.08	2. 2.22 S.	+0.17
α Bootis	*Arcturus*	1	6.21.51.55	50.45	30.53.58 N.	—0.24
α Coronæ Bor	*Alphacca*	2.3	7. 9.53.32	50.51	44.20.42 N.	—0.35
α 2 Libræ	*Zubenesch*	2.3	7.12.42.48	50.20	0.21.25 N.	—0.37
α Serpentis		2.3	7.19.41.08	50.32	25.31.27 N.	—0.40
γ Libræ		3.4	7.22.45.27	50.22	4.24.20 N.	—0.42
b Scorpii		2.3	7.28.45.00	50.18	5.27.49 S.	+0.44
δ Scorpii		3.2	8. 0.11.44	50.19	1.57.42 S.	+0.44
π Scorpii		3	8. 0.33.49	50.18	5.27. 4 S.	+0.45
β Scorpii		2	8. 0.48.49	50.20	1. 1.52 N.	—0.45
α Scorpii	Antares	1	8. 7.23.15	50.12	4.32.45 S.	+0.42
θ Ophiuchi		3	8.19. 1.10	50.20	1.49. 6 S.	+0.48
α Ophiuchi	*Ras Alhague*	2	8.20. 3.45	50.21	35.52.21 N.	—0.48
σ Sagittarii		3	9.10. 0.31	50.21	3.25.23 S.	+0.46
α Lyræ	*Vega*	1	9.12.55.38	49.89	61.44.21 N.	—0.45
π Sagittarii		3.4	9.13.52.40	50.19	1.27.41 N.	—0.45
γ Aquilæ		3	9.28.34.08	50.03	31.15.39 N.	—0.39
α Aquilæ	Altair	1.2	9.29.22.38	50.79	29.18.46 N.	+0.08
β Aquilæ		3	10. 0.03.34	50.05	26.42.28 N.	—0.38
α 2 Capricorni		3	10. 1.28.52	50.15	6.56.55 N.	—0.37
β Capricorni		3	10. 1.40.14	50.17	4.36.28 N.	—0.37
γ Capricorni		4.3	10.19.24.25	50.21	2.32.18 S.	+0.26
δ Capricorni		3	10.21. 9.29	50.21	2.33.52 S.	+0.25
α Aquarii		3	11. 0.58.57	50.11	10.40.14 N.	—0.18
α Pisca Aust	Fomalhaut	1	11. 1.27.58	50.59	21. 6.42 S.	+0.21
α Cygni	*Deneb*	1.2	11. 2.59.30	49.42	59.54.55 N.	—0.16
α Pegasi	Markab	2	11.21.07.05	50.11	19.24.45 N.	+0.10

Digitized by Google

TABLES XXXVIII., XXXIX., XL., AND XLI.

TABLE XXXVIII.

Reduct. of Lat. and Hor. Par. for Ellipticity $\frac{1}{300}$

Lat.	Reduct. of Lat.	Red. ☽ Hor. Par. Horizontal Par. 53′	57′	61′
°	′ ″	″	″	″
0	0. 0.0	0.0	0.0	0.0
2	0.47.9	0.0	0.0	0.0
4	1.35.5	0.1	0.1	0.1
6	2.22.7	0.1	0.1	0.1
8	3. 9.2	0.2	0.2	0.2
10	3.54.8	0.3	0.3	0.4
12	4.39.3	0.5	0.5	0.5
14	5.22.4	0.6	0.7	0.7
16	6. 3.9	0.8	0.9	0.9
18	6.43.7	1.0	1.1	1.2
20	7.21.5	1.2	1.3	1.4
22	7.57.2	1.5	1.6	1.7
24	8.30.7	1.8	1.9	2.0
26	9. 1.6	2.0	2.2	2.3
28	9.29.9	2.3	2.5	2.7
30	9.55.4	2.7	2.9	3.1
32	10.18.1	3.0	3.2	3.4
34	10.37.8	3.3	3.6	3.8
36	10.54.3	3.7	3.9	4.2
38	11. 7.7	4.0	4.3	4.6
40	11.17.8	4.4	4.7	5.0
42	11.24.7	4.7	5.1	5.5
44	11.28.2	5.1	5.5	5.9
46	11.28.4	5.5	5.9	6.3
48	11.25.1	5.9	6.3	6.7
50	11.18.6	6.2	6.7	7.2
52	11. 8.8	6.6	7.1	7.6
54	10.55.6	6.9	7.5	8.0
56	10.39.3	7.3	7.8	8.4
58	10.19.9	7.6	8.2	8.8
60	9.57.4	7.9	8.5	9.1
62	9.32.0	8.3	8.9	9.5
64	9. 3.8	8.6	9.2	9.9
66	8.32.9	8.8	9.5	10.2
68	7.59.6	9.1	9.8	10.5
70	7.23.8	9.4	10.1	10.8
72	6.45.9	9.6	10.3	11.0
74	6. 6.0	9.8	10.5	11.3
76	5.24.3	10.0	10.7	11.5
78	4.41.0	10.1	10.9	11.7
80	3.56.3	10.3	11.1	11.8
82	3.10.4	10.4	11.2	12.0
84	2.23.7	10.5	11.3	12.1
86	1.36.2	10.5	11.3	12.1
88	0.48.2	10.6	11.4	12.2
90	0. 0.0	10.6	11.4	12.2

TABLE XXXIX.

Aberration of Planets in Longitude.

Elong.	Uran.	Sat.	Jup.	Mars.	Venus. Elong.	Venus. Ab.	Mercury. Elong.	Mercury. Aph.	Mercury. Mea.	Mercury. Peri
D	—	—	—	—	D	—″	D	—	—	—
Con. 0	25″	27″	29″	36″	S.C. 0	43½	S.C. 0	46″	51½″	59½″
15	24	26	28	35	15	41	5	46	51	58
30	22	24	26	33	30	34	10	44	48	52
45	19	21	23	28	45	19	15	41	43	41
60	15	16	19	23	Gt. El.	14	20	37	34	
75	10	12	14	18	45	9	25	29		
90	5	6	9	12	30	0	Gt. El.	18	18	19
	+					+	25	7		
105	1	1	3	7	15	3	20	1	4	
		+	+		Inf. C.	3½		+	+	+
120	5	4	1	3			15	2	4	2
135	10	8	5	+			10	5	8	13
150	13	11	9	2			5	6	11	18
165	15	13	11	3			Inf. C.	6	11½	19½
Op. 180	15	13	11	4						

The aberration of the Sun in longitude is always 20″. The *apparent* place is given in the Nautical Almanac, and by adding 20″ the Sun's true longitude will be obtained.

TABLE XL.

Equat. Equinoxes in Longitude.

D	Long. ☽'s Node. — 0 + 6	— 1 + 7	— 2 + 8	
0	0″0	8″9	15″5	30
2	0.6	9.5	15.8	28
4	1.2	10.0	16.1	26
6	1.9	10.5	16.4	24
8	2.5	11.0	16.6	22
10	3.1	11.5	16.8	20
12	3.7	12.0	17.0	18
14	4.3	12.4	17.2	16
16	4.9	12.9	17.4	14
18	5.5	13.3	17.5	12
20	6.1	13.7	17.6	10
22	6.7	14.1	17.7	8
24	7.3	14.5	17.8	6
26	7.8	14.8	17.9	4
28	8.4	15.2	17.9	2
30	8.9	15.5	17.9	0
	— 5 + 11	— 4 + 10	— 3 + 9	D

TABLE XLI.

Aberration in Long. and Lat.

Arg. long. = ⊙ long. — ✱ long.
Arg. lat. = Arg. long. — 3 signs.

D	— 0 + 6	— 1 + 7	— 2 + 8	
0	20″0	17″3	10″0	30
2	20.0	17.0	9.4	28
4	20.0	16.6	8.8	26
6	19.9	16.2	8.1	24
8	19.8	15.8	7.5	22
10	19.7	15.3	6.8	20
12	19.6	14.9	6.2	18
14	19.4	14.4	5.5	16
16	19.2	13.9	4.8	14
18	19.0	13.4	4.2	12
20	18.8	12.9	3.5	10
22	18.5	12.3	2.8	8
24	18.3	11.8	2.1	6
26	18.0	11.2	1.4	4
28	17.7	10.6	0.7	2
30	17.3	10.0	0.0	0
	+ 5 — 11	+ 4 — 10	+ 3 — 9	D

Table XL. contains the *equation of the equinoxes* in longitude to be applied with its sign to the *mean* longitudes of all the heavenly bodies. Thus on July 16, 1830, when the longitude of the moon's ascending node was 5s. 12° 38′ the equation of the equinoxes was — 5″. 3.

The correction in Table XLI. corresponding to the Argument of Longitude being found, and its logarithm added to the log. secant (less radius) of the star's latitude, will be the log. of the star's *aberration in longitude*, to be applied with its sign to the mean longitude. The logarithm of the correction in Table XLI. corresponding to the Argument of Latitude added to the log. sine of the star's latitude will be the *aberration of the star in latitude*, to be applied with its sign to the mean latitude.

Example. Required the Aberration of *a* Pegasi, July 16, 1830?

⊙ long. 3s. 23° 22′.
✱ long. 11. 21. 07.

Arg. long. 4. 02. 15. Table 41. + 10″. 7 log. 1.02938. Arg. lat. 1s. 2°. 15′ Tab. 41. — 16″. 9 log. 1.22789
✱ Latitude 19° 25′ Sec. 0.02543. Sine 9.52171
✱ Aberr. long. + 11″3. Log. 1.05481. ✱ Aber. lat. — 5″. 6. Log. 0.74960

Digitized by Google

TABLE XLII.

Aberration in Right Ascension and Declination.

PART I. Arg. R. A. = ✱ R. A. − ⊙ Long. Arg. Dec. = Arg. R. A. + 3 signs.					PART II. Arg. R. A. = ✱ R. A. + ⊙ Long. Arg. Dec. = Arg. R A. + 3 signs.					PART III. Ar. 2d Dec. = ⊙ lon + ✱ Dec. Ar. 3d Dec. = ⊙ lon − ✱ Dec. } Ad. signs if Decl. S.				
D	0. 6. − +	1. 7. − +	2. 8. − +		D	0. 6. + −	1. 7. + −	2. 8. + −		D	0. 6. − +	1. 7. − +	2. 8. − +	
0	19″.17	16″.60	9″.59	30	0	0″.83	0″.72	0″ .41	30	0	3″.98	3″.45	1″.99	30
1	19 .17	16 .43	9 .30	29	1	0 .83	0 .71	0 .40	29	1	3 .98	3 .41	1 .93	29
2	19 .16	16 .26	9 .00	28	2	0 .83	0 .70	0 .39	28	2	3 .98	3 .38	1 .87	28
3	19 .15	16 .08	8 .70	27	3	0 .83	0 .69	0 .38	27	3	3 .98	3 .34	1 .81	27
4	19 .13	15 .90	8 .40	26	4	0 .82	0 .69	0 .36	26	4	3 .97	3 .30	1 .75	26
5	19 .10	15 .71	8 .10	25	5	0 .82	0 .68	0 .35	25	5	3 .97	3 .26	1 .68	25
6	19 .07	15 .51	7 .80	24	6	0 .82	0 .67	0 .34	24	6	3 .96	3 .22	1 .62	24
7	19 .03	15 .31	7 .49	23	7	0 .82	0 .66	0 .32	23	7	3 .95	3 .18	1 .56	23
8	18 .99	15 .11	7 .18	22	8	0 .82	0 .65	0 .31	22	8	3 .94	3 .14	1 .49	22
9	18 .94	14 .90	6 .87	21	9	0 .82	0 .64	0 .30	21	9	3 .93	3 .09	1 .43	21
10	18 .88	14 .69	6 .56	20	10	0 .81	0 .63	0 .28	20	10	3 .92	3 .05	1 .36	20
11	18 .82	14 .47	6 .24	19	11	0 .81	0 .62	0 .27	19	11	3 .91	3 .00	1 .30	19
12	18 .75	14 .25	5 .92	18	12	0 .81	0 .61	0 .26	18	12	3 .89	2 .96	1 .23	18
13	18 .68	14 .02	5 .61	17	13	0 .81	0 .60	0 .24	17	13	3 .88	2 .91	1 .16	17
14	18 .60	13 .79	5 .28	16	14	0 .80	0 .59	0 .23	16	14	3 .86	2 .86	1 .10	16
15	18 .52	13 .56	4 .96	15	15	0 .80	0 .58	0 .21	15	15	3 .85	2 .82	1 .03	15
16	18 .43	13 .32	4 .64	14	16	0 .79	0 .57	0 .20	14	16	3 .83	2 .77	0 .96	14
17	18 .34	13 .08	4 .31	13	17	0 .79	0 .56	0 .19	13	17	3 .81	2 .72	0 .90	13
18	18 .23	12 .83	3 .99	12	18	0 .79	0 .55	0 .17	12	18	3 .79	2 .66	0 .83	12
19	18 .13	12 .58	3 .66	11	19	0 .78	0 .54	0 .16	11	19	3 .76	2 .61	0 .76	11
20	18 .02	12 .32	3 .33	10	20	0 .78	0 .53	0 .14	10	20	3 .74	2 .56	0 .69	10
21	17 .90	12 .07	3 .00	9	21	0 .77	0 .52	0 .13	9	21	3 .72	2 .51	0 .62	9
22	17 .78	11 .80	2 .67	8	22	0 .77	0 .51	0 .12	8	22	3 .69	2 .45	0 .55	8
23	17 .65	11 .54	2 .34	7	23	0 .76	0 .50	0 .10	7	23	3 .66	2 .40	0 .49	7
24	17 .52	11 .27	2 .00	6	24	0 .76	0 .49	0 .09	6	24	3 .64	2 .34	0 .42	6
25	17 .38	11 .00	1 .67	5	25	0 .75	0 .47	0 .07	5	25	3 .61	2 .28	0 .35	5
26	17 .23	10 .72	1 .34	4	26	0 .74	0 .46	0 .06	4	26	3 .58	2 .23	0 .28	4
27	17 .08	10 .44	1 .00	3	27	0 .74	0 .45	0 .04	3	27	3 .55	2 .17	0 .[illegible]	3
28	16 .93	10 .16	0 .67	2	28	0 .73	0 .44	0 .03	2	28	3 .52	2 .11	0 .14	2
29	16 .77	9 .87	0 .33	1	29	0 .72	0 .43	0 .01	1	29	3 .48	2 .05	0 .07	1
30	16 .60	9 .59	0 .00	0	30	0 .72	0 .41	0 .00	0	30	3 .45	1 .99	0 .00	0
	− + 11. 5.	− + 10. 4.	− + 9. 3.	D		+ − 11. 5.	+ − 10. 4.	+ − 9. 3.	D		− + 11. 5.	− + 10. 4.	− + 9. 3.	D

To find the Aberration of a Star in Right Ascension.—Find the Equations in Part I. and II. corresponding to the arguments of R. A. at the top of those tables, and connect them according to their signs, and to the log. of this sum or difference add the log. secant (less radius) of the star's declination, the sum will be the log. of the aberration in Right Ascension in seconds of a degree, which divided by 15 will be reduced to time, to be applied to the mean R. A.

To find the Aberration of a Star in Declination.—Increase the former arguments of R. A. by 3 signs, and connect together the corresponding equations of Part I. and II. to the log. of which add the log. sine of the star's declination, the sum will be the log. of arc 1st. With the arguments at the top of Part III. find in the Table arcs 2d and 3d. These three arcs connected with their signs will be the aberration in declination, to be applied to the *mean* declination.

EXAMPLE. Required the Aberration in R. A. and Dec. of α Pegasi, July 16, 1830? By Table 8. ✱R. A.=22h. 56′ 13″=11s. 14°. 5′. ✱Dec. 14° 18′ N. and by N. A. ⊙long 3s. 23° 22′.

✱R.A. 11s. 14° 5′.
⊙Lon. 3. 23.22.

Diff. 7. 20.43. Part I.+12″.14.
Sum 3. 7.27. PartII.— 0. 11.
+12. 03. log.1.08027
✱Dec. 14° 18′ sec.0.01367
✱Aber. R. A. +· 12″. 4. log.1.09394

Diff.+3s=10s.20°.43′ Part I.—14″.24.
Sum+3 = 6 7 27 Part II.— 0 32.
—15 66 log. 1.19479
sine 9.39270
Arc 1st. —3″.87. log. 0.58749

✱Ab. in R.A. in time 0″ 83. ⊙long+✱Dec.=4s. 7° 40′ Arc 2d+2. 43.
⊙long—✱Dec.=3s. 9° 04′ Arc 3d+0. 62.
✱Aberr. in Declination —0. 82.

TABLE XLIII.

Nutation in Right Ascension and Declination to be applied to the mea.. values.

PART I.

Arg. R.A.=✱ R. A.—Lon. ☽ node. + 6 signs if Dec. is S.
Arg. Dec. = Arg R. A. + 3 signs.

D	0. 6. − +	1. 7. − +	2. 8. − +	
0	8″.33	7″.21	4″.16	30
1	8 .33	7 .14	4 .04	29
2	8 .32	7 .06	3 .91	28
3	8 .32	6 .99	3 .78	27
4	8 .31	6 .91	3 .65	26
5	8 .30	6 .82	3 .52	25
6	8 .28	6 .74	3 .39	24
7	8 .27	6 .65	3 .25	23
8	8 .25	6 .56	3 .12	22
9	8 .23	6 .47	2 .99	21
10	8 .20	6 .38	2 .85	20
11	8 .18	6 .29	2 .71	19
12	8 .15	6 .19	2 .57	18
13	8 .12	6 .09	2 .44	17
14	8 .08	5 .99	2 .30	16
15	8 .05	5 .89	2 .16	15
16	8 .01	5 .79	2 .02	14
17	7 .97	5 .68	1 .87	13
18	7 .92	5 .57	1 .73	12
19	7 .88	5 .46	1 .59	11
20	7 .83	5 .35	1 .45	10
21	7 .78	5 .24	1 .30	9
22	7 .72	5 .13	1 .16	8
23	7 .67	5 .01	1 .02	7
24	7 .61	4 .90	0 .87	6
25	7 .55	4 .78	0 .73	5
26	7 .49	4 .66	0 .58	4
27	7 .42	4 .54	0 .44	3
28	7 .35	4 .41	0 .29	2
29	7 .29	4 .29	0 .15	1
30	7 .21	4 .16	0 .00	0
	− + 11. 5.	− + 10 4.	− + 9. 3.	D

PART II.

Arg. R.A.=✱ R.A. + Lon. ☽ node. + 6 signs if Dec. is S.
Arg. Dec. = Arg. R. A. + 3 signs.

D	0. 6. − +	1. 7. − +	2. 8. − +	
0	1″.22	1″.06	0″.61	30
1	1 .22	1 .05	0 .59	29
2	1 .22	1 .03	0 .57	28
3	1 .22	1 .02	0 .55	27
4	1 .22	1 .01	0 .53	26
5	1 .22	1 .00	0 .52	25
6	1 .21	0 .99	0 .50	24
7	1 .21	0 .97	0 .48	23
8	1 .21	0 .96	0 .46	22
9	1 .20	0 .95	0 .44	21
10	1 .20	0 .93	0 .42	20
11	1 .20	0 .92	0 .40	19
12	1 .19	0 .91	0 .38	18
13	1 .19	0 .89	0 .36	17
14	1 .18	0 .88	0 .34	16
15	1 .18	0 .86	0 .32	15
16	1 .17	0 .85	0 .30	14
17	1 .17	0 .83	0 .27	13
18	1 .16	0 .82	0 .25	12
19	1 .15	0 .80	0 .23	11
20	1 .15	0 .78	0 .21	10
21	1 .14	0 .77	0 .19	9
22	1 .13	0 .75	0 .17	8
23	1 .12	0 .73	0 .15	7
24	1 .11	0 .72	0 .13	6
25	1 .11	0 .70	0 .11	5
26	1 .10	0 .68	0 .09	4
27	1 .09	0 .66	0 .06	3
28	1 .08	0 .65	0 .04	2
29	1 .07	0 .63	0 .02	1
30	1 .06	0 .61	0 .00	0
	− + 11. 5.	− + 10. 4.	− + 9. 3.	D

PART III.

Equation Equinoxes in R. A.
Arg. = Long. ☽ node ☊.

D	0. 6. − +	1. 7. − +	2. 8. − +	
0	0″ .0	8″.2	14″.2	30
1	0 .3	8 .4	14 .3	29
2	0 .6	8 .7	14 .5	28
3	0 .9	8 .9	14 .6	27
4	1 .1	9 .2	14 .7	26
5	1 .4	9 .4	14 .8	25
6	1 .7	9 .6	15 .0	24
7	2 .0	9 .9	15 .1	23
8	2 .3	10 .1	15 .2	22
9	2 .6	10 .3	15 .3	21
10	2 .8	10 .5	15 .4	20
11	3 .1	10 .7	15 .5	19
12	3 .4	11 .0	15 .6	18
13	3 .7	11 .2	15 .7	17
14	4 .0	11 .4	15 .7	16
15	4 .2	11 .6	15 .8	15
16	4 .5	11 .8	15 .9	14
17	4 .8	12 .0	16 .0	13
18	5 .1	12 .2	16 .0	12
19	5 .3	12 .4	16 .1	11
20	5 .6	12 .5	16 .1	10
21	5 .9	12 .7	16 .2	9
22	6 .1	12 .9	16 .2	8
23	6 .4	13 .1	16 .3	7
24	6 .7	13 .3	16 .3	6
25	6 .9	13 .4	16 .3	5
26	7 .2	13 .6	16 .3	4
27	7 .4	13 .7	16 .4	3
28	7 .7	13 .9	16 .4	2
29	7 .9	14 .0	16 .4	1
30	8 .2	14 .2	16 .4	0
	+ − 11. 5.	+ − 10 4.	+ − 9. 3.	D

To find the Nutation of a Star in Right Ascension.—Find in Parts I. II. the Equations corresponding to the arguments of R. A. at the top of the tables, connect them according to the signs, and to the log. of the sum or difference add the log tangent of the star's declination, the sum will be the log. of an arc, to which apply the equation of the equinoxes, Part III. corresponding to the long. of the ☽'s node (page 3, N. A.) the sum or difference will be the Nutation in Right Ascension in seconds of a degree, which divided by 15 will be reduced to seconds of time.

To find the Nutation of a Star in Declination.—Increase the arguments of R. A. Parts I. II. by 3 signs, and connect the corresponding equations of those tables, which will be the nutation of declination. *Note.* In putting the R. A. of the star equal to 3 signs, the nutation in declination will be the *equation of the obliquity of the ecliptic.*

Example. Required the Nutation of α Pegasi, in R. A. and Decl. July 16, 1830?

✱ R.A. Tab.8. 11s. 14° 5′
☽ Node N. A. 5. 12. 38

Diff. 6. 1. 27 Part I. +8″33
Sum 4. 26. 43 Part II. +6. 97

+15″30 log. 1.18469
✱ Dec. 14° 18′ tang. 9.40636

Arch +3″.9 log. 0.59105
Part III. Eq. Arg. 5s. 12° 38′ —4. 9

Nutation in Right Ascension.—1. 0=—0″ 1 of t.

Diff. + 3s = 9s 1° 27′ Part I.—0″ 21
Sum + 3s = 7. 26. 43 Part II. +0″ 67

Nut. in Dec. +0″ 46
6s.—☽ Node=0s. 17°. Part I.—7. 97
6s.+☽ Node=11s. 13. Part II.—1. 17

Eq. Obl. Eclipt. —9. 14

If the Declination of the Star was South, the argument of Part I. II. of Right Ascension and Declination must be increased 6 signs.

Digitized by Google

TABLE XLIV.

To find the Augmentation of the Moon's Semidiameter, by the altitude of the Nonagesimal, and the apparent distance of the Moon therefrom.

PART I. Arg. = Alt. nona. + ap. dist. ☾ from nona. = Alt. nona. — ap. dist. ☾ from nona.

PART II.

D.	0. +	6. —	1. +	7. —	2. +	8. —		Arg. Sum of Equat. Part I.	Corr. +
0	0.″00		4.″09		7.″09		30	1″.	0″.00
1	0. 14		4. 22		7. 16		29	2 .	0 .00
2	0. 29		4. 34		7. 23		28	3 .1	0 .01
3	0. 43		4. 46		7. 29		27	4 .4	0 .02
4	0. 57		4. 58		7. 36		26	5 .4	0 .03
5	0. 71		4. 69		7. 42		25	6 .2	0 .04
6	0. 86		4. 81		7. 48		24	6 .9	0 .05
7	1. 00		4. 93		7. 53		23	7 .6	0 .06
8	1. 14		5. 04		7. 59		22	8 .2	0 .07
9	1. 28		5. 15		7. 64		21	8 .8	0 .08
10	1. 42		5. 26		7. 69		20	9 .3	0 .09
11	1. 56		5. 37		7. 74		19	9 .8	0 .10
12	1. 70		5. 48		7. 78		18	10 .3	0 .11
13	1. 84		5. 58		7. 83		17	10 .7	0 .12
14	1. 98		5. 69		7. 87		16	11 .2	0 .13
15	2. 12		5. 79		7. 91		15	11 .6	0 .14
16	2. 26		5. 89		7. 94		14	12 .0	0 .15
17	2. 39		5. 99		7. 97		13	12 .4	0 .16
18	2. 53		6. 08		8. 01		12	12 .8	0 .17
19	2. 66		6. 18		8. 03		11	13 .1	0 .18
20	2. 80		6. 27		8. 06		10	13 .5	0 .19
21	2. 93		6. 36		8. 08		9	13 .9	0 .20
22	3. 07		6. 45		8. 10		8	14 .2	0 .21
23	3. 20		6. 54		8. 12		7	14 .5	0 .22
24	3. 33		6. 62		8. 14		6	14 .9	0 .23
25	3. 46		6. 70		8. 15		5	15 .2	0 .24
26	3. 59		6. 79		8. 16		4	15 .5	0 .25
27	3. 72		6. 86		8. 17		3	15 .8	0 .26
28	3. 84		6. 94		8. 18		2	16 .1	0 .27
29	3. 97		7. 02		8. 18		1	16 .4	0 .28
30	4. 09		7. 09		8. 18		0	16 .7	0 .29
	11. —	5. +	10. —	4. +	9. —	3. +	D.		

PART III. Argument ☾'s Parallax in Lat.

Arg. ☽'s true Latit.	0′	10′	20′	30′	40′	50′	60′
South.		—	—	—	—	—	—
6° 0′	0″.00	0″.30	0″.60	0″.92	1″.24	1″.57	1″.91
5. 0	0 .00	0 .25	0 .50	0 .77	1 .04	1 .32	1 .61
4. 0	0 .00	0 .20	0 .41	0 .62	0 .85	1 .08	1 .32
3.30	0 .00	0 .17	0 .36	0 .55	0 .75	0 .96	1 .17
3. 0	0 .00	0 .15	0 31	0 .48	0 .65	0 .83	1 .02
2.40	0 .00	0 .13	0 28	0 .43	0 .59	0 .75	0 .93
2.20	0 .00	0 .12	0 24	0 .38	0 .52	0 .67	0 .83
2. 0	0 .00	0 .10	0 21	0 .33	0 .46	0 .59	0 .73
1.40	0 .00	0 .09	0 18	0 .28	0 .39	0 .51	0 .63
1.20	0 .00	0 .07	0 15	0 .23	0 .32	0 .43	0 .54
1. 0	0 .00	0 .05	0 .11	0 .18	0 .26	0 .35	0 .44
0.40	0 .00	0 .04	0 .08	0 .13	0 .19	0 .26	0 .34
0.20	0 .00	0 .02	0 .05	0 .09	0 .13	0 .18	0 .24
0. 0	0 .00	0 .00	0 .02	0 .04	0 .06	0 .10	0 .15
North.		+					
0.10	0 .00	0 .00	+	0 .01	0 .03	0 .06	0 .10
				+			
0.20	0 .00	0 .01	0 .02	0 .01	+	0 .02	0 .05
						+	
0.30	0 .00	0 .02	0 .03	0 .04	0 .03	0 .02	+
0.40	0 .00	0 .03	0 .05	0 .06	0 .06	0 .06	0 .05
1. 0	0 .00	0 .04	0 .08	0 .11	0 .13	0 .14	0 .15
1.20	0 .00	0 .06	0 .11	0 .16	0 .19	0 .22	0 .24
1.40	0 .00	0 .08	0 .15	0 .21	0 .26	0 .30	0 .34
2. 0	0 .00	0 .09	0 .18	0 .26	0 .33	0 .39	0 .44
2.20	0 .00	0 .11	0 .21	0 .30	0 .39	0 .47	0 .54
2.40	0 .00	0 .13	0 .24	0 .35	0 .46	0 .55	0 .63
3. 0	0 .00	0 .14	0 .28	0 .40	0 .52	0 .63	0 .73
3.30	0 .00	0 .17	0 .33	0 .48	0 .62	0 .75	0 .88
4. 0	0 .00	0 .19	0 .37	0 .55	0 .72	0 .87	1 .03
5. 0	0 .00	0 .24	0 .47	0 .70	0 .91	1 .12	1 .32
6. 0	0 .00	0 .29	0 .57	0 .84	1 .11	1 .37	1 .61
		+	+	+	+	+	+
	0′	10′	20′	30′	40′	50′	60′

PART IV. Arg. ☾'s Horiz. Semi. Diam.

Arg. Sum of Pre. Eq.	14′ 40″	14′ 50″	15′ 0″	15′ 10″	15′ 20″	15′ 30″	15′ 40″	15′ 50″	16′ 0′	16′ 10″	16′ 20″	16′ 30″	16′ 40″	16′ 50″
	— ″	— ″	— ″	— ″	— ″	— ″	— ″	— ″	″	+ ″	+ ″	+ ″	+ ″	+ ″
1	0.16	0.14	0.12	0.10	0.08	0.06	0.04	0.02	0.00	0.02	0.04	0.06	0.09	0.11
2	0.32	0.28	0.24	0.20	0.16	0.12	0.08	0.04	0.00	0.04	0.08	0.13	0.17	0.21
3	0.48	0.42	0.36	0.30	0.24	0.18	0.12	0.06	0.00	0.06	0.13	0.19	0.26	0.32
4	0.64	0.56	0.48	0.41	0.33	0.25	0.16	0.08	0.00	0.08	0.17	0.25	0.34	0.43
5	0.80	0.70	0.61	0.51	0.41	0.31	0.21	0.10	0.00	0.10	0.21	0.32	0.4[illegible]	0.53
6	0.96	0.84	0.73	0.61	0.49	0.37	0.25	0.12	0.00	0.13	0.25	0.38	0.51	0.64
7	1.12	0.98	0.85	0.71	0.57	0.43	0.29	0.15	0.00	0.15	0.29	0.44	0.60	0.75
8	1.28	1.12	0.97	0.81	0.65	0.49	0.33	0.17	0.00	0.17	0.34	0.51	0.68	0.86
9	1.44	1.26	1.09	0.91	0.73	0.55	0.37	0.19	0.00	0.19	0.38	0.57	0.77	0.96
10	1.60	1.41	1.21	1.01	0.82	0.62	0.41	0.21	0.00	0.21	0.42	0.63	0.85	1.07
11	1.76	1.55	1.33	1.12	0.90	0.68	0.45	0.23	0.00	0.23	0.46	0.70	0.94	1.18
12	1.92	1.69	1.45	1.22	0.98	0.74	0.49	0.25	0 00	0.25	0.51	0.76	1.02	1.28
13	2.08	1.83	1.57	1.32	1.06	0.80	0.54	0.27	0 00	0.27	0.55	0.83	1.11	1.39
14	2.24	1.97	1.70	1.42	1.14	0.86	0.58	0.29	0.00	0.29	0.59	0.89	1.19	1.50
15	2.40	2.11	1.82	1.52	1.22	0.92	0.62	0.31	0.00	0.31	0.63	0.95	1.28	1.60
16	2.56	2.25	1.94	1.62	1.31	0.98	0.66	0.33	0.00	0.34	0.67	1.02	1.36	1.71

Find in P. I. the two equations corresponding to the arguments at the top, and connect them according to their signs. With this sum or difference, take out the corresponding correction P. II. In occultations, the correction P. III. is to be found with the ☾'s Par. in lat at the top, and her *true* lat. at the side, but in solar Eclipses, this p. is nothing. Connect these three parts, and with the sum enter the side column of P. IV., and find the ☾'s *Horiz.* Semi. Dia. at the top; the corresponding cor. applied, with its sign, to the sum of the three first parts, will give the *Aug.* of the ☾'s S. D.

Thus in Ex. 1, Prob. 5, Appendix. The Alt. Nonag. is 2s. 7° 59′, Dis. Nonag. (D.+P.) 20° 46′, ☾ S. D. by N. A. 16′ 27″. 7. Hence Arg. P. I. are 2s. 7° 59′+20° 46′, that is, 2s. 28° 45′ and 1s. 17° 13′, to which correspond + 8″ 18 + 6″.01 = + 14″ 19. This gives in P. II. + 0″ 21. P. III. is 0″. The sum of the three parts is + 14″. 4. with which and the ☾ S. D. 16′ 27″. 7. P. IV. is nearly + 0″ 8; this connected with 14″. 4 gives the Aug. of ☾'s S. D 15″ 2, as in Prob. VI. Appendix.

Digitized by Google

TABLE XLV.

Equation of Second Differences to be applied to the *mean* longitude or latitude with a sign *contrary* to that of the mean of the second differences.

App. Time after noon or midnight.		Second Difference.											
		1′	2′	3′	4′	5′	6′	7′	8′	9′	10′	11′	12′
h.m.	h. m.	″	″	″	″	″	″	″	″	″	″	″	″
0. 0	12. 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.10	11.50	0.4	0.8	1.2	1.6	2.1	2.5	2.9	3.3	3.7	4.1	4.5	4.9
0.20	11.40	0.8	1.6	2.4	3.2	4.1	4.9	5.7	6.5	7.3	8.1	8.9	9.7
0.30	11.30	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6	10.8	12.0	13.2	14.4
0.40	11.20	1.6	3.1	4.7	6.3	7.9	9.4	11.0	12.6	14.2	15.7	17.3	18.9
0.50	11.10	1.9	3.9	5.8	7.8	9.7	11.6	13.6	15.5	17.4	19.4	21.3	23.3
1. 0	11. 0	2.3	4.6	6.9	9.2	11.5	13.7	16.0	18.3	20.6	22.9	25.2	27.5
1.10	10.50	2.6	5.3	7.9	10.5	13.2	15.8	18.4	21.1	23.7	26.3	29.0	31.6
1.20	10.40	3.0	5.9	8.9	11.9	14.8	17.8	20.7	23.7	26.7	29.6	32.6	35.6
1.30	10.30	3.3	6.6	9.8	13.1	16.4	19.7	23.0	26.2	29.5	32.8	36.1	39.4
1.40	10.20	3.6	7.2	10.8	14.4	17.9	21.5	25.1	28.7	32.3	35.9	39.5	43.1
1.50	10.10	3.9	7.8	11.6	15.5	19.4	23.3	27.2	31.1	34.9	38.8	42.7	46.6
2. 0	10. 0	4.2	8.3	12.5	16.7	20.8	25.0	29.2	33.3	37.5	41.7	45.8	50.0
2.10	9.50	4.4	8.9	13.3	17.8	22.2	26.6	31.1	35.5	39.9	44.4	48.8	53.3
2.20	9.40	4.7	9.4	14.1	18.8	23.5	28.2	32.9	37.6	42.3	47.0	51.7	56.4
2.30	9.30	4.9	9.9	14.8	19.8	24.7	29.7	34.6	39.6	44.5	49.5	54.4	59.4
2.40	9.20	5.2	10.4	15.6	20.7	25.9	31.1	36.3	41.5	46.7	51.9	57.0	62.2
2.50	9.10	5.4	10.8	16.2	21.6	27.1	32.5	37.9	43.3	48.7	54.1	59.5	64.9
3. 0	9. 0	5.6	11.2	16.9	22.5	28.1	33.7	39.4	45.0	50.6	56.2	61.9	67.5
3.10	8.50	5.8	11.7	17.5	23.3	29.1	35.0	40.8	46.6	52.4	58.3	64.1	69.9
3.20	8.40	6.0	12.0	18.1	24.1	30.1	36.1	42.1	48.1	54.2	60.2	66.2	72.2
3.30	8.30	6.2	12.4	18.6	24.8	31.0	37.2	43.4	49.6	55.8	62.0	68.2	74.4
3.40	8.20	6.4	12.7	19.1	25.5	31.8	38.2	44.6	50.9	57.3	63.7	70.0	76.4
3.50	8.10	6.5	13.0	19.6	26.1	32.6	39.1	45.7	52.2	58.7	65.2	71.7	78.3
4. 0	8. 0	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0
4.20	7.40	6.9	13.8	20.8	27.7	34.6	41.5	48.4	55.4	62.3	69.2	76.1	83.1
4.40	7.20	7.1	14.3	21.4	28.5	35.6	42.8	49.9	57.0	64.2	71.3	78.4	85.6
5. 0	7. 0	7.3	14.6	21.9	29.2	36.5	43.7	51.0	58.3	65.6	72.9	80.2	87.5
5.20	6.40	7.4	14.8	22.2	29.6	37.0	44.4	51.9	59.3	66.7	74.1	81.5	88.9
5.40	6.20	7.5	15.0	22.4	29.9	37.4	44.9	52.3	59.8	67.3	74.8	82.2	89.7
6. 0	6. 0	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0

App. Time after noon or midnight.		Second Difference.													
		10″	20″	30″	40″	50″	1″	2″	3″	4″	5″	6″	7″	8″	9″
h.m.	h. m.	″	″	″	″	″	″	″	″	″	″	″	″	″	″
0. 0	12. 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.10	11.50	0.1	0.1	0.2	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
0.20	11.40	0.1	0.3	0.4	0.5	0.7	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
0.30	11.30	0.2	0.4	0.6	0.8	1.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2
0.40	11.20	0.3	0.5	0.8	1.0	1.3	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
0.50	11.10	0.3	0.6	1.0	1.3	1.6	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3
1. 0	11. 0	0.4	0.8	1.1	1.5	1.9	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3
1.10	10.50	0.4	0.9	1.3	1.8	2.2	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4
1.20	10.40	0.5	1.0	1.5	2.0	2.5	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4
1.30	10.30	0.5	1.1	1.6	2.2	2.7	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5
1.40	10.20	0.6	1.2	1.8	2.4	3.0	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.5
1.50	10.10	0.6	1.3	1.9	2.6	3.2	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.6
2. 0	10. 0	0.7	1.4	2.1	2.8	3.5	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.6	0.6
2.10	9.50	0.7	1.5	2.2	3.0	3.7	0.1	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.7
2.20	9.40	0.8	1.6	2.3	3.1	3.9	0.1	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.7
2.30	9.30	0.8	1.6	2.5	3.3	4.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.7
2.40	9.20	0.9	1.7	2.6	3.5	4.3	0.1	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8
2.50	9.10	0.9	1.8	2.7	3.6	4.5	0.1	0.2	0.3	0.4	0.5	0.5	0.6	0.7	0.8
3. 0	9. 0	0.9	1.9	2.8	3.7	4.7	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.7	0.8
3.10	8.50	1.0	1.9	2.9	3.9	4.9	0.1	[illegible]	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3.20	8.40	1.0	2.0	3.0	4.0	5.0	[illegible]	[illegible]	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3.30	8.30	1.0	2.1	3.1	4.1	5.2	[illegible]	[illegible]	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3.40	8.20	1.1	2.1	3.2	4.2	5.3	[illegible]	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0
3.50	8.10	1.1	2.2	3.3	4.3	5.4	0.1	0.2	0.3	0.4	0.5	0.7	0.8	0.9	1.0
4. 0	8. 0	1.1	2.2	3.3	4.4	5.6	0.1	0.2	0.3	0.4	0.6	0.7	0.8	0.9	1.0
4.20	7.40	1.2	2.3	3.5	4.6	5.8	0.1	0.2	0.3	0.5	0.6	0.7	0.8	0.9	1.0
4.40	7.20	1.2	2.4	3.5	4.8	5.9	0.1	0.2	0.4	0.5	0.6	0.7	0.8	1.0	1.1
5. 0	7. 0	1.2	2.4	3.6	4.9	6.1	0.1	0.2	0.4	0.5	0.6	0.7	0.9	1.0	1.1
6. 0	6. 0	1.2	2.5	3.7	5.0	6.2	0.1	0.2	0.4	0.5	0.6	0.7	0.9	1.0	1.1

Digitized by Google

TABLE XLVI.

Table showing the variation of the altitude of an object arising from a change of 100 seconds in the declination. If the change move the body towards the elevated pole, apply the correction to the altitude with the signs in the Table; otherwise, change the signs.

Dec.	Alt.	LATITUDE *Of same name as declination.* 70°	60°	50°	40°	30°	20°	10°	LATITUDE *Of different name from declination.* 0°	10°	20°	30°	40°	50°	60°	70°	Alt.	Dec.
0°	0°	94″	87″	76″	64″	50″	34″	17″	0″	17″	34″	50″	64″	76″	87″	94″	0°	0°
	10	95	88	78	65	51	35	18	0″	18	35	51	65	78	88	95	10	
	20	100	92	82	68	53	36	18	0″	18	36	53	68	82	92	100	20	
	30		100	88	74	57	39	20	0″	20	39	57	74	88	100		30	
	40			100	84	65	45	22	0″	23	45	65	84	100			40	
	50				100	78	53	27	0″	27	53	78	100				50	
	60					100	68	35	0″	35	68	100					60	
	70						100	51	0″	51	100						70	
2°	0	94	87	77	64	50	34	17	0	17	34	50	64	77	87	94	0	2°
	10	95	87	77	65	50	34	17	—1	18	35	51	66	78	88	96	10	
	20	99	91	81	67	52	35	17	—1	19	37	54	69	83	93	101	20	
	30	107	98	87	73	56	38	18	—2	22	41	59	76	90	102		30	
	40		111	98	82	63	42	20	—2	25	47	68	86	102			40	
	50			116	97	74	50	24	—3	30	57	81	103				50	
	60				124	95	64	30	—5	40	73	103					60	
	70					139	92	43	—8	59	108						70	
4°	0	94	87	77	64	50	34	17	0	17	34	50	64	77	87	94	0	4°
	10	94	87	77	64	50	34	16	—1	10	36	52	67	79	89	97	10	
	20	98	90	79	66	51	34	16	—3	21	39	56	71	84	95	103	20	
	30	105	96	85	70	54	36	16	—4	24	44	62	78	93	104		30	
	40		107	94	78	59	39	17	—6	29	51	71	90	106			40	
	50			111	92	70	45	19	—8	35	62	86	109				50	
	60				117	88	56	23	—12	47	81	112					60	
	70					127	81	32	—19	70	119						70	
6°	0	94	87	77	65	50	34	17	—0	17	34	50	65	77	87	94	0	6°
	10	94	87	76	64	49	33	16	—2	20	37	53	67	80	90	98	10	
	20	97	89	78	65	50	33	15	—4	22	40	57	73	86	96	104	20	
	30	103	94	83	69	52	34	14	—6	26	46	64	81	95	107		30	
	40		105	92	76	57	36	14	—9	32	54	74	93	109			40	
	50			107	88	66	41	15	—13	40	66	91	113				50	
	60				111	82	51	17	—18	53	87	119					60	
	70					118	72	22	—29	80	129						70	
8°	0	95	87	77	65	50	35	18	—0	18	35	50	65	77	87	95	0	8°
	10	94	86	76	63	49	33	15	—3	20	38	54	68	81	91	99	10	
	20	96	88	77	64	49	32	14	—5	24	40	59	74	87	98	106	20	
	30	101	93	81	67	50	32	12	—8	28	48	66	83	97	109		30	
	40		102	89	73	54	33	11	—12	35	57	78	[illegible]	113			40	
	50			104	84	62	37	11	—17	44	70	95	118				50	
	60				105	77	45	11	—24	59	93	125					60	
	70					109	62	13	—39	90	140						70	
10°	0	95	88	78	65	51	35	18	—0	18	35	51	65	78	88	95	0	10°
	10	94	86	75	63	48	32	15	—3	21	38	55	69	82	92	100	10	
	20	95	87	76	63	48	31	12	—6	25	43	60	76	89	100		20	
	30	100	91	80	65	49	30	10	—10	30	50	69	86	100			30	
	40		100	87	70	51	31	8	—15	38	60	81	100				40	
	50			100	81	58	33	6	—21	48	75	100					50	
	60				100	71	39	5	—31	66	100						60	
	70					100	53	3	—48	100							70	
12°	0	96	89	78	66	51	35	18	—0	18	35	51	66	78	89	96	0	12°
	10	94	86	76	63	48	32	14	—4	22	39	56	70	83	94	101	10	
	20	94	86	76	62	47	29	11	—8	27	45	62	78	91	102		20	
	30	99	90	78	64	47	28	8	—12	33	53	71	88	103			30	
	40	108	98	84	68	49	28	5	—18	41	63	85	104				40	
	50		112	97	77	54	29	2	—25	53	80	105					50	
	60			120	95	65	33	—1	—37	72	107						60	
	70				134	91	44	—6	—58	110							70	
Dec.	Alt.	70°	60°	50°	40°	30°	20°	10°	0°	10°	20°	30°	40°	50°	60°	70°	Alt.	Dec.
		LATITUDE *Of same name as declination.*							LATITUDE *Of different name from declination.*									

Digitized by Google

TABLE XLVI.

Table showing the variation of the altitude of an object arising from a change of 100 seconds in the declination. If this change move the body towards the elevated pole, apply the correction to the altitude with the signs in the Table; otherwise, change the signs.

		LATITUDE *Of same name as declination.*							LATITUDE *Of different name from declination.*									
Dec.	Alt.	70°	60°	50°	40°	30°	20°	10°	0°	10°	20°	30°	40°	50°	60°	70°	Alt.	Dec.
	0°	97″	89″	79″	66″	52″	35″	18″	0	18″	35″	52″	66″	79″	89″	97′	0°	
	10	94	86	76	63	48	31	14	—4	23	40	57	72	85	95	103	10	
	20	94	86	75	61	46	27	10	—9	28	45	64	80	93	104		20	
	30	97	89	77	62	45	26	6	—14	35	55	74	91	106			30	
14°	40	106	96	82	66	46	25	2	—21	44	67	88	107				40	14°
	50		109	93	73	50	25	—2	—30	58	85	110					50	
	60			115	89	60	27	—7	—43	79	114						60	
	70				125	82	35	—16	—69	121							70	
	0	98	90	80	67	52	36	18	—0	18	36	52	67	80	90	98	0	
	10	94	86	76	63	48	31	13	—5	23	41	58	73	86	97	104	10	
	20	94	85	74	61	45	27	9	—10	30	48	66	82	95	106		20	
	30	96	87	75	61	44	25	4	—17	37	58	77	94	109			30	
16°	40	104	94	80	63	44	22	0	—24	48	70	92	111				40	16°
	50		106	90	70	47	21	—6	—34	62	90	115					50	
	60			110	84	54	21	—14	—50	86	121						60	
	70				117	73	25	—26	—79	132							70	
	0	99	91	81	68	53	36	18	—0	18	36	53	68	81	91	99	0	
	10	95	87	76	63	48	31	13	—6	24	42	59	74	88	98	106	10	
	20	93	85	74	60	44	26	8	—12	31	50	68	84	98	109		20	
	30	95	86	74	59	42	23	2	—19	40	60	79	97	112			30	
18°	40	102	92	78	61	41	20	—3	—27	51	74	96	116				40	18°
	50		103	87	66	43	17	—10	—39	67	95	121					50	
	60			105	79	49	16	—20	—56	93	128						60	
	70				108	64	16	—36	—89	143							70	
	0	100	92	82	68	53	36	18	—0	18	36	53	68	82	92	100	0	
	10	95	87	76	63	48	31	12	—6	25	43	60	76	89	100		10	
	20	93	85	74	60	43	25	6	—13	33	52	70	86	100			20	
	30	94	85	73	58	40	21	0	—21	42	63	82	100				30	
20°	40	100	90	76	59	39	17	—6	—31	55	78	100					40	20°
	50		100	83	63	39	13	—15	—43	72	100						50	
	60			100	74	43	10	—26	—63	100							60	
	70				100	56	6	—46	—100								70	
	0		93	83	69	54	37	19	—0	19	37	54	69	83	93	101	0	
	10	96	88	77	63	48	30	12	—7	26	45	62	78	91	102		10	
	20	93	85	73	59	43	25	5	—15	35	54	72	88	103			20	
	30	94	85	72	57	39	19	—2	—23	45	66	86	103				30	
22°	40	98	88	74	57	36	14	—9	—34	58	82	104					40	22°
	50	110	97	80	60	36	9	—19	—48	77	106						50	
	60		117	95	68	38	4	—33	—70	107							60	
	70			131	92	47	—3	—56	—111								70	
	0		95	84	70	55	37	19	—0	19	37	55	70	84	95	103	0	
	10	97	88	77	64	48	30	11	—8	27	46	63	79	93	104		10	
	20	93	85	73	59	42	24	4	—16	36	56	74	91	105			20	
	30	93	84	71	56	38	18	—4	—26	48	69	89	107				30	
24°	40	97	86	72	54	34	12	—12	—37	62	86	109					40	24°
	50	107	93	77	56	32	5	—23	—53	83	111						50	
	60		112	91	64	32	—2	—39	—77	115							60	
	70			123	83	38	—13	—67	—122								70	
	0		96	85	72	56	38	19	—0	19	38	56	72	85	96	105	0	
	10	98	89	78	64	48	30	11	—9	28	47	65	81	95	106		10	
	20	95	85	73	59	41	23	3	—18	38	58	77	94	108			20	
	30	93	83	70	54	36	16	—6	—28	50	72	92	111				30	
26°	40	96	85	70	52	32	9	—16	—41	66	91	114					40	26°
	50	105	92	74	53	28	1	—28	—58	88	117						50	
	60		108	86	58	27	—8	—46	—84	123							60	
	70			115	75	29	—23	—78	—134								70	
Dec.	Alt.	70°	60°	50°	40°	30°	20°	10°	0°	10°	20°	30°	40°	50°	60°	70°	Alt.	Dec.
		LATITUDE *Of same name as declination.*							LATITUDE *Of different name from declination.*									

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	1° 7′	1° 8′	1° 9′	1° 10′	1° 11′	1° 12′	1° 13′	1° 14′	1° 15′	1° 16′	
0	9.8879	9.8898	9.8917	9.8935	9.8954	9.8973	9.8992	9.9012	9.9031	9.9050	60
1	8879	8898	8917	8936	8955	8974	8993	9012	9031	9051	59
2	8880	8898	8917	8936	8955	8974	8993	9012	9032	9051	58
3	8880	8899	8918	8936	8955	8974	8993	9013	9032	9051	57
4	8880	8899	8918	8937	8956	8975	8994	9013	9032	9052	56
5	9.8881	9.8899	9.8918	9.8937	9.8956	9.8975	9.8994	9.9013	9.9033	9.9052	55
6	8881	8900	8918	8937	8956	8975	8994	9014	9033	9052	54
7	8881	8900	8919	8938	8957	8976	8995	9014	9033	9053	53
8	8882	8900	8919	8938	8957	8976	8995	9014	9033	9053	52
9	8882	8901	8919	8938	8957	8976	8995	9015	9034	9053	51
10	9.8882	9.8901	9.8920	9.8939	9.8958	9.8977	9.8996	9.9015	9.9034	9.9053	50
11	8883	8901	8920	8939	8958	8977	8996	9015	9034	9054	49
12	8883	8902	8920	8939	8958	8977	8996	9015	9035	9054	48
13	8883	8902	8921	8940	8958	8978	8997	9016	9035	9054	47
14	8884	8902	8921	8940	8959	8978	8997	9016	9035	9055	46
15	9.8884	9.8903	9.8921	9.8940	9.8959	9.8978	9.8997	9.9016	9.9036	9.9055	45
16	8884	8903	8922	8940	8959	8978	8998	9017	9036	9055	44
17	8884	8903	8922	8941	8960	8979	8998	9017	9036	9056	43
18	8885	8903	8922	8941	8960	8979	8998	9017	9037	9056	42
19	8885	8904	8923	8941	8960	8979	8999	9018	9037	9056	41
20	9.8885	9.8904	9.8923	9.8942	9.8961	9.8980	9.8999	9.9018	9.9037	9.9057	40
21	8886	8904	8923	8942	8961	8980	8999	9018	9038	9057	39
22	8886	8905	8924	8942	8961	8980	8999	9019	9038	9057	38
23	8886	8905	8924	8943	8962	8981	9000	9019	9038	9058	37
24	8887	8905	8924	8943	8962	8981	9000	9019	9039	9058	36
25	9.8887	9.8906	9.8924	9.8943	9.8962	9.8981	9.9000	9.9020	9.9039	9.9058	35
26	8887	8906	8925	8944	8963	8982	9001	9020	9039	9059	34
27	8888	8906	8925	8944	8963	8982	9001	9020	9040	9059	33
28	8888	8907	8925	8945	8963	8982	9001	9021	9040	9059	32
29	8888	8907	8926	8945	8964	8983	9002	9021	9040	9060	31
30	9.8888	9.8907	9.8926	9.8945	9.8964	9.8983	9.9002	9.9021	9.9041	9.9060	30
31	8889	8908	8926	8945	8964	8983	9002	9022	9041	9060	29
32	8889	8908	8927	8946	8964	8984	9003	9022	9041	9061	28
33	8889	8908	8927	8946	8965	8984	9003	9022	9042	9061	27
34	8890	8908	8927	8946	8965	8984	9003	9023	9042	9061	26
35	9.8890	9.8909	9.8928	9.8946	9.8965	9.8985	9.9004	9.9023	9.9042	9.9062	25
36	8890	8909	8928	8947	8966	8985	9004	9023	9042	9062	24
37	8891	8909	8928	8947	8966	8985	9004	9024	9043	9062	23
38	8891	8910	8929	8947	8966	8985	9005	9024	9043	9063	22
39	8891	8910	8929	8948	8967	8986	9005	9024	9043	9063	21
40	9.8892	9.8910	9.8929	9.8948	9.8967	9.8986	9.9005	9.9024	9.9044	9.9063	20
41	8892	8911	8929	8948	8967	8986	9006	9025	9044	9064	19
42	8892	8911	8930	8949	8968	8987	9006	9025	9044	9064	18
43	8893	8911	8930	8949	8968	8987	9006	9025	9045	9064	17
44	8893	8912	8930	8949	8968	8987	9007	9026	9045	9064	16
45	9.8893	9.8912	9.8931	9.8950	9.8969	9.8988	9.9007	9.9026	9.9045	9.9065	15
46	8893	8912	8931	8950	8969	8988	9007	9026	9046	9065	14
47	8894	8913	8931	8950	8969	8988	9007	9027	9046	9065	13
48	8894	8913	8932	8951	8970	8989	9008	9027	9046	9066	12
49	8894	8913	8932	8951	8970	8989	9008	9027	9047	9066	11
50	9.8895	9.8913	9.8932	9.8951	9.8970	9.8989	9.9008	9.9028	9.9047	9.9066	10
51	8895	8914	8933	8952	8971	8990	9009	9028	9047	9067	9
52	8895	8914	8933	8952	8971	8990	9009	9028	9048	9067	8
53	8896	8914	8933	8952	8971	8990	9009	9029	9048	9067	7
54	8896	8915	8934	8952	8971	8991	9010	9029	9048	9068	6
55	9.8896	9.8915	9.8934	9.8953	9.8972	9.8991	9.9010	9.9029	9.9049	9.9068	5
56	8897	8915	8934	8953	8972	8991	9010	9030	9049	9068	4
57	8897	8916	8935	8953	8972	8992	9011	9030	9049	9069	3
58	8897	8916	8935	8954	8973	8992	9011	9030	9050	9069	2
59	8898	8916	8935	8954	8973	8992	9011	9031	9050	9069	1
60	8898	8917	8935	8954	8973	8992	9012	9031	9050	9070	0
	8° 52′	8° 51′	8° 50′	8° 49′	8° 48′	8° 47′	8° 46′	8° 45′	8° 44′	8° 43′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	1° 17′	1° 18′	1° 19′	1° 20′	1° 21′	1° 22′	1° 23′	1° 24′	1° 25′	1° 26′	
0	9.9070	9.9089	9.9109	9.9128	9.9148	9.9168	9.9188	9.9208	9.9228	9.9249	60
1	9070	9090	9109	9129	9149	9168	9188	9209	9229	9249	59
2	9070	9090	9109	9129	9149	9169	9189	9209	9229	9249	58
3	9071	9090	9110	9129	9149	9169	9189	9209	9229	9250	57
4	9071	9091	9110	9130	9150	9169	9189	9210	9230	9250	56
5	9.9071	9.9091	9.9110	9.9130	9.9150	9.9170	9.9190	9.9210	9.9230	9.9250	55
6	9072	9091	9111	9130	9150	9170	9190	9210	9230	9251	54
7	9072	9091	9111	9131	9151	9170	9190	9211	9231	9251	53
8	9072	9092	9111	9131	9151	9171	9191	9211	9231	9251	52
9	9073	9092	9112	9131	9151	9171	9191	9211	9231	9252	51
10	9.9073	9.9092	9.9112	9.9132	9.9152	9.9171	9.9191	9.9212	9.9232	9.9252	50
11	9073	9093	9112	9132	9152	9172	9192	9212	9232	9252	49
12	9074	9093	9113	9132	9152	9172	9192	9212	9232	9253	48
13	9074	9093	9113	9133	9153	9172	9192	9213	9233	9253	47
14	9074	9094	9113	9133	9153	9173	9193	9213	9233	9253	46
15	9.9075	9.9094	9.9114	9.9133	9.9153	9.9173	9.9193	9.9213	9.9233	9.9254	45
16	9075	9094	9114	9134	9154	9173	9193	9214	9234	9254	44
17	9075	9095	9114	9134	9154	9174	9194	9214	9234	9254	43
18	9076	9095	9115	9134	9154	9174	9194	9214	9234	9255	42
19	9076	9095	9115	9135	9155	9174	9194	9215	9235	9255	41
20	9.9076	9.9096	9.9115	9.9135	9.9155	9.9175	9.9195	9.9215	9.9235	9.9255	40
21	9076	9096	9116	9135	9155	9175	9195	9215	9235	9256	39
22	9077	9096	9116	9136	9156	9175	9195	9216	9236	9256	38
23	9077	9097	9116	9136	9156	9176	9196	9216	9236	9256	37
24	9077	9097	9117	9136	9156	9176	9196	9216	9236	9257	36
25	9.9078	9.9097	9.9117	9.9137	9.9157	9.9176	9.9196	9.9217	9.9237	9.9257	35
26	9078	9098	9117	9137	9157	9177	9197	9217	9237	9257	34
27	9078	9098	9118	9137	9157	9177	9197	9217	9237	9258	33
28	9079	9098	9118	9138	9158	9177	9197	9218	9238	9258	32
29	9079	9099	9118	9138	9158	9178	9198	9218	9238	9258	31
30	9.9079	9.9099	9.9119	9.9138	9.9158	9.9178	9.9198	9.9218	9.9238	9.9259	30
31	9080	9099	9119	9139	9159	9178	9198	9219	9239	9259	29
32	9080	9100	9119	9139	9159	9179	9199	9219	9239	9259	28
33	9080	9100	9120	9139	9159	9179	9199	9219	9239	9260	27
34	9081	9100	9120	9140	9160	9179	9199	9220	9240	9260	26
35	9.9081	9.9101	9.9120	9.9140	9.9160	9.9180	9.9200	9.9220	9.9240	9.9260	25
36	9081	9101	9121	9140	9160	9180	9200	9220	9240	9261	24
37	9082	9101	9121	9141	9161	9180	9200	9221	9241	9261	23
38	9082	9102	9121	9141	9161	9181	9201	9221	9241	9261	22
39	9082	9102	9122	9141	9161	9181	9201	9221	9241	9262	21
40	9.9083	9.9102	9.9122	9.9142	9.9162	9.9181	9.9201	9.9222	9.9242	9.9262	20
41	9083	9103	9122	9142	9162	9182	9202	9222	9242	9262	19
42	9083	9103	9123	9142	9162	9182	9202	9222	9243	9263	18
43	9084	9103	9123	9143	9163	9182	9202	9223	9243	9263	17
44	9084	9104	9123	9143	9163	9183	9203	9223	9243	9263	16
45	9.9084	9.9104	9.9124	9.9143	9.9163	9.9183	9.9203	9.9223	9.9244	9.9264	15
46	9085	9104	9124	9144	9164	9183	9203	9224	9244	9264	14
47	9085	9105	9124	9144	9164	9184	9204	9224	9244	9265	13
48	9085	9105	9125	9144	9164	9184	9204	9224	9245	9265	12
49	9086	9105	9125	9145	9165	9184	9205	9225	9245	9265	11
50	9.9086	9.9106	9.9125	9.9145	9.9165	9.9185	9.9205	9.9225	9.9245	9.9266	10
51	9086	9106	9126	9145	9165	9185	9205	9225	9246	9266	9
52	9087	9106	9126	9146	9166	9185	9206	9226	9246	9266	8
53	9087	9107	9126	9146	9166	9186	9206	9226	9246	9267	7
54	9087	9107	9127	9146	9166	9186	9206	9226	9247	9267	6
55	9.9088	9.9107	9.9127	9.9147	9.9167	9.9186	9.9207	9.9227	9.9247	9.9267	5
56	9088	9107	9127	9147	9167	9187	9207	9227	9247	9268	4
57	9088	9108	9128	9147	9167	9187	9207	9227	9248	9268	3
58	9089	9108	9128	9148	9167	9187	9208	9228	9248	9268	2
59	9089	9108	9128	9148	9168	9188	9208	9228	9248	9269	1
60	9089	9109	9128	9148	9168	9188	9208	9228	9249	9269	0
	8° 42′	8° 41′	8° 40′	8° 39′	8° 38′	8° 37′	8° 36′	8° 35′	8° 34′	8° 33′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	1° 27′	1° 28′	1° 29′	1° 30′	1° 31′	1° 32′	1° 33′	1° 34′	1° 35′	1° 36′	
0	9.9269	9.9289	9.9310	9.9331	9.9351	9.9372	9.9393	9.9414	9.9435	9.9456	60
1	9269	9290	9310	9331	9352	9372	9393	9414	9436	9457	59
2	9270	9290	9311	9331	9352	9373	9394	9415	9436	9457	58
3	9270	9290	9311	9332	9352	9373	9394	9415	9436	9457	57
4	9270	9291	9311	9332	9353	9373	9394	9415	9437	9458	56
5	9.9271	9.9291	9.9312	9.9332	9.9353	9.9374	9.9395	9.9416	9.9437	9.9458	55
6	9271	9291	9312	9333	9353	9374	9395	9416	9437	9459	54
7	9271	9292	9312	9333	9354	9375	9395	9417	9438	9459	53
8	9272	9292	9313	9333	9354	9375	9396	9417	9438	9459	52
9	9272	9292	9313	9334	9354	9375	9396	9417	9438	9460	51
10	9.9272	9.9293	9.9313	9.9334	9.9355	9.9376	9.9397	9.9418	9.9439	9.9460	50
11	9273	9293	9314	9334	9355	9376	9397	9418	9439	9460	49
12	9273	9293	9314	9335	9355	9376	9397	9418	9439	9461	48
13	9273	9294	9314	9335	9356	9377	9398	9419	9440	9461	47
14	9274	9294	9315	9335	9356	9377	9398	9419	9440	9461	46
15	9.9274	9.9294	9.9315	9.9336	9.9356	9.9377	9.9398	9.9419	9.9440	9.9462	45
16	9274	9295	9315	9336	9357	9378	9399	9420	9441	9462	44
17	9275	9295	9316	9336	9357	9378	9399	9420	9441	9462	43
18	9275	9296	9316	9337	9358	9378	9399	9420	9342	9463	42
19	9275	9296	9316	9337	9358	9379	9400	9421	9442	9463	41
20	9.9276	9.9296	9.9317	9.9337	9.9358	9.9379	9.9400	9.9421	9.9442	9.9464	40
21	9276	9297	9317	9338	9359	9379	9400	9421	9443	9464	39
22	9276	9297	9317	9338	9359	9380	9401	9422	9443	9464	38
23	9277	9297	9318	9338	9359	9380	9401	9422	9443	9465	37
24	9277	9298	9318	9339	9360	9380	9401	9422	9444	9465	36
25	9.9277	9.9298	9.9318	9.9339	9.9360	9.9381	9.9402	9.9423	9.9444	9.9465	35
26	9278	9298	9319	9340	9360	9381	9402	9423	9444	9466	34
27	9278	9299	9319	9340	9361	9381	9402	9424	9445	9466	33
28	9278	9299	9320	9340	9361	9382	9403	9424	9445	9466	32
29	9279	9299	9320	9341	9361	9382	9403	9424	9445	9467	31
30	9.9279	9.9300	9.9320	9.9341	9.9362	9.9383	9.9404	9.9425	9.9446	9.9467	30
31	9279	9300	9321	9341	9362	9383	9404	9425	9446	9467	29
32	9280	9300	9321	9342	9362	9383	9404	9425	9447	9468	28
33	9280	9301	9321	9342	9363	9384	9405	9426	9447	9468	27
34	9280	9301	9322	9342	9363	9384	9405	9426	9447	9469	26
35	9.9281	9.9301	9.9322	9.9343	9.9363	9.9384	9.9405	9.9426	9.9448	9.9469	25
36	9281	9302	9322	9343	9364	9385	9406	9427	9448	9469	24
37	9282	9302	9323	9343	9364	9385	9406	9427	9448	9470	23
38	9282	9302	9323	9344	9364	9385	9406	9427	9449	9470	22
39	9282	9303	9323	9344	9365	9386	9407	9428	9449	9470	21
40	9.9283	9.9303	9.9324	9.9344	9.9365	9.9386	9.9407	9.9428	9.9449	9.9471	20
41	9283	9303	9324	9345	9365	9386	9407	9428	9450	9471	19
42	9283	9304	9324	9345	9366	9387	9408	9429	9450	9471	18
43	9284	9304	9325	9345	9366	9387	9408	9429	9450	9472	17
44	9284	9304	9325	9346	9367	9387	9408	9430	9451	9472	16
45	9.9284	9.9305	9.9325	9.9346	9.9367	9.9388	9.9409	9.9430	9.9451	9.9472	15
46	9285	9305	9326	9346	9367	9388	9409	9430	9451	9473	14
47	9285	9305	9326	9347	9368	9388	9409	9431	9452	9473	13
48	9285	9306	9326	9347	9368	9389	9410	9431	9452	9473	12
49	9286	9306	9327	9347	9368	9389	9410	9431	9453	9474	11
50	9.9286	9.9306	9.9327	9.9348	9.9369	9.9390	9.9411	9.9432	9.9453	9.9474	10
51	9286	9307	9327	9348	9369	9390	9411	9432	9453	9475	9
52	9287	9307	9328	9348	9369	9390	9411	9432	9454	9475	8
53	9287	9308	9328	9349	9370	9391	9412	9433	9454	9475	7
54	9287	9308	9328	9349	9370	9391	9412	9433	9454	9476	6
55	9.9288	9.9308	9.9329	9.9350	9.9370	9.9391	9.9412	9.9433	9.9455	9.9476	5
56	9288	9309	9329	9350	9371	9392	9413	9434	9455	9476	4
57	9288	9309	9329	9350	9371	9392	9413	9434	9455	9477	3
58	9289	9309	9330	9351	9371	9392	9413	9434	9456	9477	2
59	9289	9310	9330	9351	9372	9393	9414	9435	9456	9477	1
60	9289	9310	9331	9351	9372	9393	9414	9435	9456	9478	0
	8° 32′	8° 31′	8° 30′	8° 29′	8° 28′	8° 27′	8° 26′	8° 25′	8° 24′	8° 23′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

′	1° 37′	1° 38′	1° 39′	1° 40′	1° 41′	1° 42′	1° 43′	1° 44′	1° 45′	1° 46′	
0	9.9478	9.9499	9.9521	9.9542	9.9564	9.9586	9.9608	9.9630	9.9652	9.9675	60
1	9478	9500	9521	9543	9565	9586	9608	9631	9653	9675	59
2	9478	9500	9521	9543	9565	9587	9609	9631	9653	9675	58
3	9479	9500	9522	9544	9565	9587	9609	9631	9653	9676	57
4	9479	9501	9522	9544	9566	9588	9610	9632	9654	9676	56
5	9.9480	9.9501	9.9523	9.9544	9.9566	9.9588	9.9610	9.9632	9.9654	9.9677	55
6	9480	9501	9523	9545	9566	9588	9610	9632	9655	9677	54
7	9480	9502	9523	9545	9567	9589	9611	9633	9655	9677	53
8	9481	9502	9524	9545	9567	9589	9611	9633	9655	9678	52
9	9481	9502	9524	9546	9567	9589	9611	9633	9656	9678	51
10	9.9481	9.9503	9.9524	9.9546	9.9568	9.9590	9.9612	9.9634	9.9656	9.9678	50
11	9482	9503	9525	9546	9568	9590	9612	9634	9656	9679	49
12	9482	9504	9525	9547	9569	9590	9612	9635	9657	9679	48
13	9482	9504	9525	9547	9569	9591	9613	9635	9657	9680	47
14	9483	9504	9526	9547	9569	9591	9613	9635	9658	9680	46
15	9.9483	9.9505	9.9526	9.9548	9.9570	9.9592	9.9614	9.9636	9.9658	9.9680	45
16	9483	9505	9527	9548	9570	9592	9614	9636	9658	9681	44
17	9484	9505	9527	9549	9570	9592	9614	9636	9659	9681	43
18	9484	9506	9527	9549	9571	9593	9615	9637	9659	9681	42
19	9485	9506	9528	9549	9571	9593	9615	9637	9659	9682	41
20	9.9485	9.9506	9.9528	9.9550	9.9571	9.9593	9.9615	9.9638	9.9660	9.9682	40
21	9485	9507	9528	9550	9572	9594	9616	9638	9660	9683	39
22	9486	9507	9529	9550	9572	9594	9616	9638	9661	9683	38
23	9486	9507	9529	9551	9573	9594	9617	9639	9661	9683	37
24	9486	9508	9529	9551	9573	9595	9617	9639	9661	9684	36
25	9.9487	9.9508	9.9530	9.9551	9.9573	9.9595	9.9617	9.9639	9.9662	9.9684	35
26	9487	9509	9530	9552	9574	9596	9618	9640	9662	9684	34
27	9487	9509	9530	9552	9574	9596	9618	9640	9662	9685	33
28	9488	9509	9531	9553	9574	9596	9618	9641	9663	9685	32
29	9488	9510	9531	9553	9575	9597	9619	9641	9663	9686	31
30	9.9488	9.9510	9.9532	9.9553	9.9575	9.9597	9.9619	9.9641	9.9664	9.9686	30
31	9489	9510	9532	9554	9575	9597	9619	9642	9664	9686	29
32	9489	9511	9532	9554	9576	9598	9620	9642	9664	9687	28
33	9490	9511	9533	9554	9576	9598	9620	9642	9665	9687	27
34	9490	9511	9533	9555	9577	9599	9621	9643	9665	9687	26
35	9.9490	9.9512	9.9533	9.9555	9.9577	9.9599	9.9621	9.9643	9.9665	9.9688	25
36	9491	9512	9534	9555	9577	9599	9621	9643	9666	9688	24
37	9491	9512	9534	9556	9578	9600	9622	9644	9666	9689	23
38	9491	9513	9534	9556	9578	9600	9622	9644	9667	9689	22
39	9492	9513	9535	9557	9578	9600	9622	9645	9667	9689	21
40	9.9492	9.9514	9.9535	9.9557	9.9579	9.9601	9.9623	9.9645	9.9667	9.9690	20
41	9492	9514	9536	9557	9579	9601	9623	9645	9668	9690	19
42	9493	9514	9536	9558	9579	9601	9624	9646	9668	9690	18
43	9493	9515	9536	9558	9580	9602	9624	9646	9668	9691	17
44	9493	9515	9537	9558	9580	9602	9624	9646	9669	9691	16
45	9.9494	9.9515	9.9537	9.9559	9.9581	9.9603	9.9625	9.9647	9.9669	9.9692	15
46	9494	9516	9537	9559	9581	9603	9625	9647	9669	9692	14
47	9495	9516	9538	9559	9581	9603	9625	9648	9670	9692	13
48	9495	9516	9538	9560	9582	9604	9626	9648	9670	9693	12
49	9495	9517	9538	9560	9582	9604	9626	9648	9671	9693	11
50	9.9496	9.9517	9.9539	9.9561	9.9583	9.9604	9.9626	9.9649	9.9671	9.9693	10
51	9496	9518	9539	9561	9583	9605	9627	9649	9671	9694	9
52	9496	9518	9540	9561	9583	9605	9627	9649	9672	9694	8
53	9497	9518	9540	9562	9584	9605	9628	9650	9672	9695	7
54	9497	9519	9540	9562	9584	9606	9628	9650	9672	9695	6
55	9.9497	9.9519	9.9541	9.9562	9.9584	9.9606	9.9628	9.9651	9.9673	9.9695	5
56	9498	9519	9541	9563	9585	9607	9629	9651	9673	9696	4
57	9498	9520	9541	9563	9585	9607	9629	9651	9674	9696	3
58	9498	9520	9542	9563	9585	9607	9629	9652	9674	9696	2
59	9499	9520	9542	9564	9586	9608	9630	9652	9674	9697	1
60	9499	9521	9542	9564	9586	9608	9630	9652	9675	9697	0
	8° 22′	8° 21′	8° 20′	8° 19′	8° 18′	8° 17′	8° 13′	8° 15′	8° 14′	8° 13′	′

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

TABLE XLVII.

The *first* correction is always to be taken at the *top*.
The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

"	1° 47′	1° 48′	1° 49′	1° 50′	1° 51′	1° 52′	1° 53′	1° 54′	1° 55′	1° 56′	
0	9.9697	9.9720	9.9742	9.9765	9.9788	9.9811	9.9834	9.9858	9.9881	9.9905	60
1	9698	9720	9743	9766	9788	9812	9835	9858	9881	9905	59
2	9698	9720	9743	9766	9789	9812	9835	9858	9882	9905	58
3	9698	9721	9744	9766	9789	9812	9835	9859	9882	9906	57
4	9699	9721	9744	9767	9790	9813	9836	9859	9883	9906	56
5	9.9699	9.972[illegible]	9.9744	9.9767	9.9790	9.9813	9.9836	9.9860	9.9883	9.9907	55
6	9699	9722	9745	9767	9790	9813	9837	9860	9883	9907	54
7	9700	9722	9745	9768	9791	9814	9837	9860	9884	9907	53
8	9700	9723	9745	9768	9791	9814	9837	9861	9884	9908	52
9	9701	9723	9746	9769	9792	9815	9838	9861	9885	9908	51
10	9.9701	9.9723	9.9746	9.9769	9.9792	9.9815	9.9838	9.9861	9.9885	9.9908	50
11	9701	9724	9747	9769	9792	9815	9839	9862	9885	9909	49
12	9702	9724	9747	9770	9793	9816	9839	9862	9886	9909	48
13	9702	9725	9747	9770	9793	9816	9839	9863	9886	9910	47
14	9702	9725	9748	9771	9793	9817	9840	9863	9886	9910	46
15	9.9703	9.9725	9.9748	9.9771	9.9794	9.9817	9.9840	9.9863	9.9887	9.9910	45
16	9703	9726	9748	9771	9794	9817	9841	9864	9887	9911	44
17	9704	9726	9749	9772	9795	9818	9841	9864	9888	9911	43
18	9704	9727	9749	9772	9795	9818	9841	9865	9888	9912	42
19	9704	9727	9750	9772	9795	9818	9842	9865	9888	9912	41
20	9.9705	9.9727	9.9750	9.9773	9.9796	9.9819	9.9842	9.9865	9.9889	9.9912	40
21	9705	9728	9750	9773	9796	9819	9842	9866	9889	9913	39
22	9705	9728	9751	9774	9797	9820	9843	9866	9890	9913	38
23	9706	9728	9751	9774	9797	9820	9843	9867	9890	9914	37
24	9706	9729	9751	9774	9797	9820	9844	9867	9890	9914	36
25	9.9707	9.9729	9.9752	9.9775	9.9798	9.9821	9.9844	9.9867	9.9891	9.9914	35
26	9707	9730	9752	9775	9798	9821	9844	9868	9891	9915	34
27	9707	9730	9753	9775	9798	9822	9845	9868	9892	9915	33
28	9708	9730	9753	9776	9799	9822	9845	9869	9892	9916	32
29	9708	9731	9753	9776	9799	9822	9846	9869	9892	9916	31
30	9.9708	9.9731	9.9754	9.9777	9.9800	9.9823	9.9846	9.9869	9.9893	9.9916	30
31	9709	9731	9754	9777	9800	9823	9846	9870	9893	9917	29
32	9709	9732	9755	9777	9800	9823	9847	9870	9894	9917	28
33	9710	9732	9755	9778	9801	9824	9847	9870	9894	9918	27
34	9710	9733	9755	9778	9801	9824	9847	9871	9894	9918	26
35	9.9710	9.9733	9.9756	9.9779	9.9802	9.9825	9.9848	9.9871	9.9895	9.9918	25
36	9711	9733	9756	9779	9802	9825	9848	9872	9895	9919	24
37	9711	9734	9756	9779	9802	9825	9849	9872	9896	9919	23
38	9711	9734	9757	9780	9803	9826	9849	9872	9896	9920	22
39	9712	9734	9757	9780	9803	9826	9849	9873	9896	9920	21
40	9.9712	9.9735	9.9758	9.9780	9.9803	9.9827	9.9850	9.9873	9.9897	9.9920	20
41	9713	9735	9758	9781	9804	9827	9850	9874	9897	9921	19
42	9713	9736	9758	9781	9804	9827	9851	9874	9897	9921	18
43	9713	9736	9759	9782	9805	9828	9851	9874	9898	9921	17
44	9714	9736	9759	9782	9805	9828	9851	9875	9898	9922	16
45	9.9714	9.9737	9.9759	9.9782	9.9805	9.9829	9.9852	9.9875	9.9899	9.9922	15
46	9714	9737	9760	9783	9806	9829	9852	9876	9899	9923	14
47	9715	9737	9760	9783	9806	9829	9853	9876	9899	9923	13
48	9715	9738	9761	9784	9807	9830	9853	9876	9900	9923	12
49	9716	9738	9761	9784	9807	9830	9853	9877	9900	9924	11
50	9.9716	9.9739	9.9761	9.9784	9.9807	9.983[illegible]	9.9854	9.9877	9.9901	9.9924	10
51	9716	9739	9762	9785	9808	9831	9854	9877	9901	9925	9
52	9717	9739	9762	9785	9808	9831	9854	9878	9901	9925	8
53	9717	9740	9763	9785	9808	9832	9855	9878	9902	9925	7
54	9717	9740	9763	9786	9809	9832	9855	9879	9902	9926	6
55	9.9718	9.9740	9.9763	9.9786	9.9809	9.9832	9.9856	9.9879	9.9903	9.9926	5
56	9718	9741	9764	9787	9810	9833	9856	9879	9903	9927	4
57	9719	9741	9764	9787	9810	9833	9856	9880	9903	9927	3
58	9719	9742	9764	9787	9810	9834	9857	9880	9904	9927	2
59	9719	9742	9765	9788	9811	9834	9857	9881	9904	9928	1
60	9720	9742	9765	9788	9811	9834	9858	9881	9905	9928	0
	8° 12′	8° 11′	8° 10′	8° 9′	8° 8′	8° 7′	8° 6′	8° 5′	8° 4′	8° 3′	"

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	1° 57′	1° 58′	1° 59′	2° 0′	2° 1′	2° 2′	2° 3′	2° 4′	2° 5′	2° 6′	2° 7′	
0	9.9928	9.9952	9.9976	0.0000	0.0024	0.0049	0.0073	0.0098	0.0122	0.0147	0.0172	60
1	9929	9952	9976	0000	0025	0049	0073	0098	0123	0148	0173	59
2	9929	9953	9977	0001	0025	0049	0074	0098	0123	0148	0173	58
3	9929	9953	9977	0001	0025	0050	0074	0099	0124	0148	0174	57
4	9930	9954	9978	0002	0026	0050	0075	0099	0124	0149	0174	56
5	9.9930	9.9954	9.9978	0.0002	0.0026	0.0051	0.0075	0.0100	0.0124	0.0149	0.0174	55
6	9931	9954	9978	0002	0027	0051	0075	0100	0125	0150	0175	54
7	9931	9955	9979	0003	0027	0051	0076	0100	0125	0150	0175	53
8	9931	9955	9979	0003	0027	0052	0076	0101	0126	0151	0176	52
9	9932	9956	9980	0004	0028	0052	0077	0101	0126	0151	0176	51
10	9.9932	9.9956	9.9980	0.0004	0.0028	0.0053	0.0077	0.0102	0.0126	0.0151	0.0176	50
11	9933	9956	9980	0004	0029	0053	0077	0102	0127	0152	0177	49
12	9933	9957	9981	0005	0029	0053	0078	0103	0127	0152	0177	48
13	9933	9957	9981	0005	0029	0054	0078	0103	0128	0153	0178	47
14	9934	9958	9982	0006	0030	0054	0079	0103	0128	0153	0178	46
15	9.9934	9.9958	9.9982	0.0006	0.0030	0.0055	0.0079	0.0104	0.0129	0.0153	0.0179	45
16	9935	9958	9982	0006	0031	0055	0080	0104	0129	0154	0179	44
17	9935	9959	9983	0007	0031	0055	0080	0105	0129	0154	0179	43
18	9935	9959	9983	0007	0031	0056	0080	0105	0130	0155	0180	42
19	9936	9960	9984	0008	0032	0056	0081	0105	0130	0155	0180	41
20	9.9936	9.9960	9.9984	0.0008	0.0032	0.0057	0.0081	0.0106	0.0131	0.0156	0.0181	40
21	9937	9960	9984	0008	0033	0057	0082	0106	0131	0156	0181	39
22	9937	9961	9985	0009	0033	0057	0082	0107	0131	0156	0181	38
23	9937	9961	9985	0009	0034	0058	0082	0107	0132	0157	0182	37
24	9938	9962	9986	0010	0034	0058	0083	0107	0132	0157	0182	36
25	9.9938	9.9962	9.9986	0.0010	0.0034	0.0059	0.0083	0.0108	0.0133	0.0158	0.0183	35
26	9939	9962	9986	0010	0035	0059	0084	0108	0133	0158	0183	34
27	9939	9963	9987	0011	0035	0060	0084	0109	0134	0158	0184	33
28	9939	9963	9987	0011	0036	0060	0084	0109	0134	0159	0184	32
29	9940	9964	9988	0012	0036	0060	0085	0110	0134	0159	0184	31
30	9.9940	9.9964	9.9988	0.0012	0.0036	0.0061	0.0085	0.0110	0.0135	0.0160	0.0185	30
31	9940	9964	9988	0012	0037	0061	0086	0110	0135	0160	0185	29
32	9941	9965	9989	0013	0037	0062	0086	0111	0136	0161	0186	28
33	9941	9965	9989	0013	0038	0062	0087	0111	0136	0161	0186	27
34	9942	9966	9990	0014	0038	0062	0087	0112	0136	0161	0187	26
35	9.9942	9.9966	9.9990	0.0014	0.0038	0.0063	0.0087	0.0112	0.0137	0.0162	0.0187	25
36	9942	9966	9990	0015	0039	0063	0088	0112	0137	0162	0187	24
37	9943	9967	9991	0015	0039	0064	0088	0113	0138	0163	0188	23
38	9943	9967	9991	0015	0040	0064	0089	0113	0138	0163	0188	22
39	9944	9968	9992	0016	0040	0064	0089	0114	0139	0163	0189	21
40	9.9944	9.9968	9.9992	0.0016	0.0040	0.0065	0.0089	0.0114	0.0139	0.0164	0.0189	20
41	9944	9968	9992	0017	0041	0065	0090	0114	0139	0164	0189	19
42	9945	9969	9993	0017	0041	0066	0090	0115	0140	0165	0190	18
43	9945	9969	9993	0017	0042	0066	0091	0115	0140	0165	0190	17
44	9946	9970	9994	0018	0042	0066	0091	0116	0141	0166	0191	16
45	9.9946	9.9970	9.9994	0.0018	0.0042	0.0067	0.0091	0.0116	0.0141	0.0166	0.0191	15
46	9946	9970	9994	0019	0043	0067	0092	0117	0141	0166	0192	14
47	9947	9971	9995	0019	0043	0068	0092	0117	0142	0167	0192	13
48	9947	9971	9995	0019	0044	0068	0093	0117	0142	0167	0192	12
49	9948	9972	9996	0020	0044	0068	0093	0118	0143	0168	0193	11
50	9.9948	9.9972	9.9996	0.0020	0.0044	0.0069	0.0093	0.0118	0.0143	0.0168	0.0193	10
51	9948	9972	9996	0021	0045	0069	0094	0119	0143	0169	0194	9
52	9949	9973	9997	0021	0045	0070	0094	0119	0144	0169	0194	8
53	9949	9973	9997	0021	0046	0070	0095	0119	0144	0169	0194	7
54	9950	9974	9998	0022	0046	0071	0095	0120	0145	0170	0195	6
55	9.9950	9.9974	9.9998	0.0022	0.0046	0.0071	0.0096	0.0120	0.0145	0.0170	0.0195	5
56	9950	9974	9998	0023	0047	0071	0096	0121	0146	0171	0196	4
57	9951	9975	9999	0023	0047	0072	0096	0121	0146	0171	0196	3
58	9951	9975	9999	0023	0048	0072	0097	0122	0146	0171	0197	2
59	9952	9976	0.0000	0024	0048	0073	0097	0122	0147	0172	0197	1
60	9952	9976	0000	0024	0049	0073	0098	0122	0147	0172	0197	0
	8° 2′	8° 1′	8° 0′	7° 59′	7° 58′	7° 57′	7° 56′	7° 55′	7° 54′	7° 53′	7° 52′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	2° 8′	2° 9′	2° 10′	2° 11′	2° 12′	2° 13′	2° 14′	2° 15′	2° 16′	2° 17′	2° 18′	
0	0.0197	0.0223	0.0248	0.0274	0.0300	0.0326	0.0352	0.0378	0.0404	0.0431	0.0458	60
1	0198	0223	0249	0274	0300	0326	0352	0378	0405	0431	0458	59
2	0198	0224	0249	0275	0300	0326	0353	0379	0405	0432	0458	58
3	0199	0224	0250	0275	0301	0327	0353	0379	0406	0432	0459	57
4	0199	0224	0250	0276	0301	0327	0353	0380	0406	0433	0459	56
5	0.0200	0.0225	0.0250	0.0276	0.0302	0.0328	0.0354	0.0380	0.0406	0.0433	0.0460	55
6	0200	0225	0251	0276	0302	0328	0354	0381	0407	0434	0460	54
7	0200	0226	0251	0277	0303	0329	0355	0381	0407	0434	0461	53
8	0201	0226	0252	0277	0303	0329	0355	0381	0408	0434	0461	52
9	0201	0227	0252	0278	0304	0329	0356	0382	0408	0435	0462	51
10	0.0202	0.0227	0.0252	0.0278	0.0304	0.0330	0.0356	0.0382	0.0409	0.0435	0.0462	50
11	0202	0227	0253	0279	0304	0330	0356	0383	0409	0436	0462	49
12	0202	0228	0253	0279	0305	0331	0357	0383	0410	0436	0463	48
13	0203	0228	0254	0279	0305	0331	0357	0384	0410	0437	0463	47
14	0203	0229	0254	0280	0306	0332	0358	0384	0410	0437	0464	46
15	0.0204	0.0229	0.0255	0.0280	0.0306	0.0332	0.0358	0.0384	0.0411	0.0438	0.0464	45
16	0204	0230	0255	0281	0307	0333	0359	0385	0411	0438	0465	44
17	0205	0230	0255	0281	0307	0333	0359	0385	0412	0438	0465	43
18	0205	0230	0256	0282	0307	0333	0359	0386	0412	0439	0466	42
19	0205	0231	0256	0282	0308	0334	0360	0386	0413	0439	0466	41
20	0.0206	0.0231	0.0257	0.0282	0.0308	0.0334	0.0360	0.0387	0.0413	0.0440	0.0467	40
21	0206	0232	0257	0283	0309	0335	0361	0387	0414	0440	0467	39
22	0207	0232	0258	0283	0309	0335	0361	0388	0414	0441	0467	38
23	0207	0233	0258	0284	0310	0336	0362	0388	0414	0441	0468	37
24	0208	0233	0258	0284	0310	0336	0362	0388	0415	0442	0468	36
25	0.0208	0.0233	0.0259	0.0285	0.0310	0.0336	0.0363	0.0389	0.0415	0.0442	0.0469	35
26	0208	0234	0259	0285	0311	0337	0363	0389	0416	0442	0469	34
27	0209	0234	0260	0285	0311	0337	0363	0390	0416	0443	0470	33
28	0209	0235	0260	0286	0312	0338	0364	0390	0417	0443	0470	32
29	0210	0235	0261	0286	0312	0338	0364	0391	0417	0444	0471	31
30	0.0210	0.0235	0.0261	0.0287	0.0313	0.0339	0.0365	0.0391	0.0418	0.0444	0.0471	30
31	0211	0236	0261	0287	0313	0339	0365	0392	0418	0445	0471	29
32	0211	0236	0262	0288	0313	0339	0366	0392	0418	0445	0472	28
33	0211	0237	0262	0288	0314	0340	0366	0392	0419	0446	0472	27
34	0212	0237	0263	0288	0314	0340	0366	0393	0419	0446	0473	26
35	0.0212	0.0238	0.0263	0.0289	0.0315	0.0341	0.0367	0.0393	0.0420	0.0446	0.0473	25
36	0213	0238	0264	0289	0315	0341	0367	0394	0420	0447	0474	24
37	0213	0238	0264	0290	0316	0342	0368	0394	0421	0447	0474	23
38	0213	0239	0264	0290	0316	0342	0368	0395	0421	0448	0475	22
39	0214	0239	0265	0291	0316	0342	0369	0395	0422	0448	0475	21
40	0.0214	0.0240	0.0265	0.0291	0.0317	0.0343	0.0369	0.0395	0.0422	0.0449	0.0475	20
41	0215	0240	0266	0291	0317	0343	0370	0396	0422	0449	0476	19
42	0215	0241	0266	0292	0318	0344	0370	0396	0423	0450	0476	18
43	0216	0241	0267	0292	0318	0344	0370	0397	0423	0450	0477	17
44	0216	0241	0267	0293	0319	0345	0371	0397	0424	0450	0477	16
45	0.0216	0.0242	0.0267	0.0293	0.0319	0.0345	0.0371	0.0398	0.0424	0.0451	0.0478	15
46	0217	0242	0268	0294	0319	0346	0372	0398	0425	0451	0478	14
47	0217	0243	0268	0294	0320	0346	0372	0399	0425	0452	0479	13
48	0218	0243	0269	0294	0320	0346	0373	0399	0426	0452	0479	12
49	0218	0244	0269	0295	0321	0347	0373	0399	0426	0453	0480	11
50	0.0219	0.0244	0.0270	0.0295	0.0321	0.0347	0.0374	0.0400	0.0426	0.0453	0.0480	10
51	0219	0244	0270	0296	0322	0348	0374	0400	0427	0454	0480	9
52	0219	0245	0270	0296	0322	0348	0374	0401	0427	0454	0481	8
53	0220	0245	0271	0297	0323	0349	0375	0401	0428	0454	0481	7
54	0220	0246	0271	0297	0323	0349	0375	0402	0428	0455	0482	6
55	0.0221	0.0246	0.0272	0.0297	0.0323	0.0349	0.0376	0.0402	0.0429	0.0455	0.0482	5
56	0221	0247	0272	0298	0324	0350	0376	0403	0429	0456	0483	4
57	0221	0247	0273	0298	0324	0350	0377	0403	0430	0456	0483	3
58	0222	0247	0273	0299	0325	0351	0377	0403	0430	0457	0484	2
59	0222	0248	0273	0299	0325	0351	0377	0404	0430	0457	0484	1
60	0223	0248	0274	0300	0326	0352	0378	0404	0431	0458	0484	0
	7° 51′	7° 50′	7° 49′	7° 48′	7° 47′	7° 46′	7° 45′	7° 44′	7° 43′	7° 42′	7° 41′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.
The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	2° 19′	2° 20′	2° 21′	2° 22′	2° 23′	2° 24′	2° 25′	2° 26′	2° 27′	2° 28′	2° 29′	
0	0.0484	0.0512	0.0539	0.0566	0.0594	0.0621	0.0649	0.0678	0.0706	0.0734	0.0763	60
1	0485	0512	0539	0567	0594	0622	0650	0678	0706	0735	0763	59
2	0485	0512	0540	0567	0595	0622	0650	0678	0707	0735	0764	58
3	0486	0513	0540	0568	0595	0623	0651	0679	0707	0736	0764	57
4	0486	0513	0541	0568	0596	0623	0651	0679	0708	0736	0765	56
5	0.0487	0.0514	0.0541	0.0568	0.0596	0.0624	0.0652	0.0680	0.0708	0.0737	0.0765	55
6	0487	0514	0541	0569	0596	0624	0652	0680	0709	0737	0766	54
7	0488	0515	0542	0569	0597	0625	0653	0681	0709	0738	0766	53
8	0488	0515	0542	0570	0597	0625	0653	0681	0710	0738	0767	52
9	0489	0516	0543	0570	0598	0626	0654	0682	0710	0739	0767	51
10	0.0489	0.0516	0.0543	0.0571	0.0598	0.0626	0.0654	0.0682	0.0711	0.0739	0.0768	50
11	0489	0517	0544	0571	0599	0627	0655	0683	0711	0740	0768	49
12	0490	0517	0544	0572	0599	0627	0655	0683	0711	0740	0769	48
13	0490	0517	0545	0572	0600	0628	0655	0684	0712	0740	0769	47
14	0491	0518	0545	0573	0600	0628	0656	0684	0712	0741	0770	46
15	0.0491	0.0518	0.0546	0.0573	0.0601	0.0628	0.0656	0.0685	0.0713	0.0741	0.0770	45
16	0492	0519	0546	0573	0601	0629	0657	0685	0713	0742	0771	44
17	0492	0519	0546	0574	0602	0629	0657	0686	0714	0742	0771	43
18	0493	0520	0547	0574	0602	0630	0658	0686	0714	0743	0772	42
19	0493	0520	0547	0575	0602	0630	0658	0686	0715	0743	0772	41
20	0.0493	0.0521	0.0548	0.0575	0.0603	0.0631	0.0659	0.0687	0.0715	0.0744	0.0773	40
21	0494	0521	0548	0576	0603	0631	0659	0687	0716	0744	0773	39
22	0494	0521	0549	0576	0604	0632	0660	0688	0716	0745	0774	38
23	0495	0522	0549	0577	0604	0632	0660	0688	0717	0745	0774	37
24	0495	0522	0550	0577	0605	0633	0661	0689	0717	0746	0774	36
25	0.0496	0.0523	0.0550	0.0578	0.0605	0.0633	0.0661	0.0689	0.0718	0.0746	0.0775	35
26	0496	0523	0551	0578	0606	0634	0662	0690	0718	0747	0775	34
27	0497	0524	0551	0579	0606	0634	0662	0690	0719	0747	0776	33
28	0497	0524	0552	0579	0607	0634	0663	0691	0719	0748	0776	32
29	0498	0525	0552	0579	0607	0635	0663	0691	0720	0748	0777	31
30	0.0498	0.0525	0.0552	0.0580	0.0608	0.0635	0.0663	0.0692	0.0720	0.0749	0.0777	30
31	0498	0526	0553	0580	0608	0636	0664	0692	0721	0749	0778	29
32	0499	0526	0553	0581	0609	0636	0664	0693	0721	0750	0778	28
33	0499	0526	0554	0581	0609	0637	0665	0693	0721	0750	0779	27
34	0500	0527	0554	0582	0609	0637	0665	0694	0722	0751	0779	26
35	0.0500	0.0527	0.0555	0.0582	0.0610	0.0638	0.0666	0.0694	0.0722	0.0751	0.0780	25
36	0501	0528	0555	0583	0610	0638	0666	0694	0723	0751	0780	24
37	0501	0528	0556	0583	0611	0639	0667	0695	0723	0752	0781	23
38	0502	0529	0556	0584	0611	0639	0667	0695	0724	0752	0781	22
39	0502	0529	0557	0584	0612	0640	0668	0696	0724	0753	0782	21
40	0.0502	0.0530	0.0557	0.0585	0.0612	0.0640	0.0668	0.0696	0.0725	0.0753	0.0782	20
41	0503	0530	0557	0585	0613	0641	0669	0697	0725	0754	0783	19
42	0503	0531	0558	0585	0613	0641	0669	0697	0726	0754	0783	18
43	0504	0531	0558	0586	0614	0641	0670	0698	0726	0755	0784	17
44	0504	0531	0559	0586	0614	0642	0670	0698	0727	0755	0784	16
45	0.0505	0.0532	0.0559	0.0587	0.0615	0.0642	0.0670	0.0699	0.0727	0.0756	0.0785	15
46	0505	0532	0560	0587	0615	0643	0671	0699	0728	0756	0785	14
47	0506	0533	0560	0588	0615	0643	0671	0700	0728	0757	0786	13
48	0506	0533	0561	0588	0616	0644	0672	0700	0729	0757	0786	12
49	0507	0534	0561	0589	0616	0644	0672	0701	0729	0758	0787	11
50	0.0507	0.0534	0.0562	0.0589	0.0617	0.0645	0.0673	0.0701	0.0730	0.0758	0.0787	10
51	0507	0535	0562	0590	0617	0645	0673	0702	0730	0759	0787	9
52	0508	0535	0562	0590	0618	0646	0674	0702	0730	0759	0788	8
53	0508	0536	0563	0591	0618	0646	0674	0703	0731	0760	0788	7
54	0509	0536	0563	0591	0619	0647	0675	0703	0731	0760	0789	6
55	0.0509	0.0536	0.0564	0.0591	0.0619	0.0647	0.0675	0.0703	0.0732	0.0761	0.0789	5
56	0510	0537	0564	0592	0620	0648	0675	0704	0732	0761	0790	4
57	0510	0537	0565	0592	0620	0648	0676	0704	0733	0762	0790	3
58	0511	0538	0565	0593	0621	0648	0677	0705	0733	0762	0791	2
59	0511	0538	0566	0593	0621	0649	0677	0705	0734	0762	0791	1
60	0512	0539	0566	0594	0621	0649	0678	0706	0734	0763	0792	0
	7° 40′	7° 39′	7° 38′	7° 37′	7° 36′	7° 35′	7° 34′	7° 33′	7° 32′	7° 31′	7° 30′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

"	2° 30′	2° 31′	2° 32′	2° 33′	2° 34′	2° 35′	2° 36′	2° 37′	2° 38′	2° 39′	2° 40′	
0	0.0792	0.0821	0.0850	0.0880	0.0909	0.0939	0.0969	0.0999	0.1030	0.1061	0.1091	60
1	0792	0821	0851	0880	0910	0940	0970	1000	1030	1061	1092	59
2	0793	0822	0851	0881	0910	0940	0970	1000	1031	1062	1092	58
3	0793	0822	0852	0881	0911	0941	0971	1001	1031	1062	1093	57
4	0794	0823	0852	0882	0911	0941	0971	1001	1032	1063	1094	56
5	0.0794	0.0823	0.0853	0.0882	0.0912	0.0942	0.0972	0.1002	0.1032	0.1063	0.1094	55
6	0795	0824	0853	0883	0912	0942	0972	1002	1033	1064	1095	54
7	0795	0824	0854	0883	0913	0943	0973	1003	1033	1064	1095	53
8	0796	0825	0854	0883	0913	0943	0973	1003	1034	1065	1096	52
9	0796	0825	0855	0884	0914	0944	0974	1004	1034	1065	1096	51
10	0.0797	0.0826	0.0855	0.0884	0.0914	0.0944	0.0974	0.1004	0.1035	0.1066	0.1097	50
11	0797	0826	0855	0885	0915	0945	0975	1005	1035	1066	1097	49
12	0798	0827	0856	0885	0915	0945	0975	1005	1036	1067	1098	48
13	0798	0827	0856	0886	0916	0946	0976	1006	1036	1067	1098	47
14	0799	0828	0857	0886	0916	0946	0976	1006	1037	1068	1099	46
15	0.0799	0.0828	0.0857	0.0887	0.0917	0.0947	0.0977	0.1007	0.1037	0.1068	0.1099	45
16	0800	0829	0858	0887	0917	0947	0977	1007	1038	1069	1100	44
17	0800	0829	0858	0888	0918	0948	0978	1008	1039	1069	1100	43
18	0801	0830	0859	0888	0918	0948	0978	1008	1039	1070	1101	42
19	0801	0830	0859	0889	0919	0949	0979	1009	1040	1070	1101	41
20	0.0801	0.0831	0.0860	0.0889	0.0919	0.0949	0.0979	0.1009	0.1040	0.1071	0.1102	40
21	0802	0831	0860	0890	0920	0950	0980	1010	1041	1071	1102	39
22	0802	0832	0861	0890	0920	0950	0980	1011	1041	1072	1103	38
23	0803	0832	0861	0891	0921	0951	0981	1011	1042	1072	1103	37
24	0803	0833	0862	0891	0921	0951	0981	1012	1042	1073	1104	36
25	0.0804	0.0833	0.0862	0.0892	0.0922	0.0952	0.0982	0.1012	0.1043	0.1073	0.1104	35
26	0804	0834	0863	0892	0922	0952	0982	1013	1043	1074	1105	34
27	0805	0834	0863	0893	0923	0953	0983	1013	1044	1074	1105	33
28	0805	0834	0864	0893	0923	0953	0983	1014	1044	1075	1106	32
29	0806	0835	0864	0894	0924	0954	0984	1014	1045	1075	1106	31
30	0.0806	0.0835	0.0865	0.0894	0.0924	0.0954	0.0984	0.1015	0.1045	0.1076	0.1107	30
31	0807	0836	0865	0895	0925	0955	0985	1015	1046	1076	1108	29
32	0807	0836	0866	0895	0925	0955	0985	1016	1046	1077	1108	28
33	0808	0837	0866	0896	0926	0956	0986	1016	1047	1078	1109	27
34	0808	0837	0867	0896	0926	0956	0986	1017	1047	1078	1109	26
35	0.0809	0.0838	0.0867	0.0897	0.0927	0.0957	9.0987	0.1017	0.1048	0.1079	0.1110	25
36	0809	0838	0868	0897	0927	0957	0987	1018	1048	1079	1110	24
37	0810	0839	0868	0898	0928	0958	0988	1018	1049	1080	1111	23
38	0810	0839	0869	0898	0928	0958	0988	1019	1049	1080	1111	22
39	0811	0840	0869	0899	0929	0959	0989	1019	1050	1081	1112	21
40	0.0811	0.0840	0.0870	0.0899	0.0929	0.0959	0.0989	0.1020	0.1050	0.1081	0.1112	20
41	0812	0841	0870	0900	0930	0960	0990	1020	1051	1082	1113	19
42	0812	0841	0871	0900	0930	0960	0990	1021	1051	1082	1113	18
43	0813	0842	0871	0901	0931	0961	0991	1021	1052	1083	1114	17
44	0813	0842	0872	0901	0931	0961	0991	1022	1052	1083	1114	16
45	0.0814	0.0843	0.0872	0.0902	0.0932	0.0962	0.0992	0.1022	0.1053	0.1084	0.1115	15
46	0814	0843	0873	0902	0932	0962	0992	1023	1053	1084	1115	14
47	0815	0844	0873	0903	0933	0963	0993	1023	1054	1085	1116	13
48	0815	0844	0874	0903	0933	0963	0993	1024	1054	1085	1116	12
49	0816	0845	0874	0904	0934	0964	0994	1024	1055	1086	1117	11
50	0.0816	0.0845	0.0875	0.0904	0.0934	0.0964	0.0994	0.1025	0.1055	0.1086	0.1117	10
51	0816	0846	0875	0905	0935	0965	0995	1025	1056	1087	1118	9
52	0817	0846	0876	0905	0935	0965	0995	1026	1056	1087	1118	8
53	0817	0847	0876	0906	0936	0966	0996	1026	1057	1088	1119	7
54	0818	0847	0877	0906	0936	0966	0996	1027	1057	1088	1119	6
55	0.0818	0.0848	0.0877	0.0907	0.0937	0.0967	0.0997	0.1027	0.1058	0.1089	0.1120	5
56	0819	0848	0878	0907	0937	0967	0997	1028	1058	1089	1120	4
57	0819	0849	0878	0908	0938	0968	0998	1028	1059	1090	1121	3
58	0820	0849	0879	0908	0938	0968	0998	1029	1060	1090	1122	2
59	0820	0850	0879	0909	0939	0969	0999	1029	1060	1091	1122	1
60	0821	0850	0880	0909	0939	0969	0999	1030	1061	1091	1123	0
	7° 29′	7° 28′	7° 27′	7° 26′	7° 25′	7° 24′	7° 23′	7° 22′	7° 21′	7° 20′	7° 19′	"

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

TABLE XLVII.

The *first* correction is always to be taken at the *top*.
The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	2° 41′	2° 42′	2° 43′	2° 44′	2° 45′	2° 46′	2° 47′	2° 48′	2° 49′	2° 50′	2° 51′	
0	0.1123	0.1154	0.1186	0.1217	0.1249	0.1282	0.1314	0.1347	0.1380	0.1413	0.1447	60
1	1123	1154	1186	1218	1250	1282	1315	1348	1381	1414	1447	59
2	1124	1155	1187	1218	1250	1283	1315	1348	1381	1414	1448	58
3	1124	1156	1187	1219	1251	1283	1316	1349	1382	1415	1449	57
4	1125	1156	1188	1219	1252	1284	1316	1349	1382	1416	1449	56
5	0.1125	0.1157	0.1188	0.1220	0.1252	0.1284	0.1317	0.1350	0.1383	0.1416	0.1450	55
6	1126	1157	1189	1221	1253	1285	1317	1350	1383	1417	1450	54
7	1126	1158	1189	1221	1253	1285	1318	1351	1384	1417	1451	53
8	1127	1158	1190	1222	1254	1286	1319	1351	1384	1418	1451	52
9	1127	1159	1190	1222	1254	1287	1319	1352	1385	1418	1452	51
10	0.1128	0.1159	0.1191	0.1223	0.1255	0.1287	0.1320	0.1352	0.1386	0.1419	0.1452	50
11	1128	1160	1191	1223	1255	1288	1320	1353	1386	1419	1453	49
12	1129	1160	1192	1224	1256	1288	1321	1354	1387	1420	1454	48
13	1129	1161	1192	1224	1256	1289	1321	1354	1387	1421	1454	47
14	1130	1161	1193	1225	1257	1289	1322	1355	1388	1421	1455	46
15	0.1130	0.1162	0.1193	0.1225	0.1257	0.1290	0.1322	0.1355	0.1388	0.1422	0.1455	45
16	1131	1162	1194	1226	1258	1290	1323	1356	1389	1422	1456	44
17	1131	1163	1195	1226	1259	1291	1323	1356	1389	1423	1456	43
18	1132	1163	1195	1227	1259	1291	1324	1357	1390	1423	1457	42
19	1132	1164	1196	1227	1260	1292	1325	1357	1391	1424	1458	41
20	0.1133	0.1164	0.1196	0.1228	0.1260	0.1292	0.1325	0.1358	0.1391	0.1424	0.1458	40
21	1134	1165	1197	1229	1261	1293	1326	1359	1392	1425	1459	39
22	1134	1165	1197	1229	1261	1294	1326	1359	1392	1426	1459	38
23	1135	1166	1198	1230	1262	1294	1327	1360	1393	1426	1460	37
24	1135	1167	1198	1230	1262	1295	1327	1360	1393	1427	1460	36
25	0.1136	0.1167	0.1199	0.1231	0.1263	0.1295	0.1328	0.1361	0.1394	0.1427	0.1461	35
26	1136	1168	1199	1231	1263	1296	1328	1361	1394	1428	1461	34
27	1137	1168	1200	1232	1264	1296	1329	1362	1395	1428	1462	33
28	1137	1169	1200	1232	1264	1297	1329	1362	1396	1429	1463	32
29	1138	1169	1201	1233	1265	1297	1330	1363	1396	1429	1463	31
30	0.1138	0.1170	0.1201	0.1233	0.1266	0.1298	0.1331	0.1363	0.1397	0.1430	0.1464	30
31	1139	1170	1202	1234	1266	1298	1331	1364	1397	1431	1464	29
32	1139	1171	1202	1234	1267	1299	1332	1365	1398	1431	1465	28
33	1140	1171	1203	1235	1267	1300	1332	1365	1398	1432	1465	27
34	1140	1172	1204	1235	1268	1300	1333	1366	1399	1432	1466	26
35	0.1141	0.1172	0.1204	0.1236	0.1268	0.1301	0.1333	0.1366	0.1399	0.1433	0.1467	25
36	1141	1173	1205	1237	1269	1301	1334	1367	1400	1433	1467	24
37	1142	1173	1205	1237	1269	1302	1334	1367	1401	1434	1468	23
38	1142	1174	1206	1238	1270	1302	1335	1368	1401	1435	1468	22
39	1143	1174	1206	1238	1270	1303	1335	1368	1402	1435	1469	21
40	0.1143	0.1175	0.1207	0.1239	0.1271	0.1303	0.1336	0.1369	0.1402	0.1436	0.1469	20
41	1144	1175	1207	1239	1271	1304	1337	1370	1403	1436	1470	19
42	1145	1176	1208	1240	1272	1304	1337	1370	1403	1437	1470	18
43	1145	1177	1208	1240	1273	1305	1338	1371	1404	1437	1471	17
44	1146	1177	1209	1241	1273	1306	1338	1371	1404	1438	1472	16
45	0.1146	0.1178	0.1209	0.1241	0.1274	0.1306	0.1339	0.1372	0.1405	0.1438	0.1472	15
46	1147	1178	1210	1242	1274	1307	1339	1372	1406	1439	1473	14
47	1147	1179	1210	1242	1275	1307	1340	1373	1406	1440	1473	13
48	1148	1179	1211	1243	1275	1308	1340	1373	1407	1440	1474	12
49	1148	1180	1211	1243	1276	1308	1341	1374	1407	1441	1474	11
50	0.1149	0.1180	0.1212	0.1244	0.1276	0.1309	0.1342	0.1374	0.1408	0.1441	0.1475	10
51	1149	1181	1213	1245	1277	1309	1342	1375	1408	1442	1476	9
52	1150	1181	1213	1245	1277	1310	1343	1376	1409	1442	1476	8
53	1150	1182	1214	1246	1278	1310	1343	1376	1409	1443	1477	7
54	1151	1182	1214	1246	1278	1311	1344	1377	1410	1443	1477	6
55	0.1151	0.1183	0.1215	0.1247	0.1279	0.1311	0.1344	0.1377	0.1411	0.1444	0.1478	5
56	1152	1183	1215	1247	1280	1312	1345	1378	1411	1445	1478	4
57	1152	1184	1216	1248	1280	1313	1345	1378	1412	1445	1479	3
58	1153	1184	1216	1243	1281	1313	1346	1379	1412	1446	1479	2
59	1153	1185	1217	1249	1281	1314	1346	1379	1413	1446	1480	1
60	1154	1186	1217	1249	1282	1314	1347	1380	1413	1447	1481	0
	7° 18′	7° 17′	7° 16′	7° 15′	7° 14′	7° 13′	7° 12′	7° 11′	7° 10′	7° 9′	7° 8′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	2° 52′	2° 53′	2° 54′	2° 55′	2° 56′	2° 57′	2° 58′	2° 59′	3° 0′	3° 1′	3° 2′	
0	0.1481	0.1515	0.1549	0.1584	0.1619	0.1654	0.1689	0.1725	0.1761	0.1797	0.1834	60
1	1481	1515	1550	1584	1619	1654	1690	1725	1762	1798	1835	59
2	1482	1516	1550	1585	1620	1655	1690	1726	1762	1798	1835	58
3	1482	1516	1551	1585	1620	1655	1691	1727	1763	1799	1836	57
4	1483	1517	1551	1586	1621	1656	1692	1727	1763	1800	1836	56
5	0.1483	0.1518	0.1552	0.1587	0.1621	0.1657	0.1692	0.1728	0.1764	0.1800	0.1837	55
6	1484	1518	1552	1587	1622	1657	1693	1728	1765	1801	1838	54
7	1485	1519	1553	1588	1623	1658	1693	1729	1765	1802	1838	53
8	1485	1519	1554	1588	1623	1658	1694	1730	1766	1802	1839	52
9	1486	1520	1554	1589	1624	1659	1694	1730	1766	1803	1839	51
10	0.1486	0.1520	0.1555	0.1589	0.1624	0.1660	0.1695	0.1731	0.1767	0.1803	0.1840	50
11	1487	1521	1555	1590	1625	1660	1696	1731	1768	1804	1841	49
12	1487	1522	1556	1591	1626	1661	1696	1732	1768	1805	1841	48
13	1488	1522	1556	1591	1626	1661	1697	1733	1769	1805	1842	47
14	1489	1523	1557	1592	1627	1662	1697	1733	1769	1806	1843	46
15	0.1489	0.1523	0.1558	0.1592	0.1627	0.1663	0.1698	0.1734	0.1770	0.1806	0.1843	45
16	1490	1524	1558	1593	1628	1663	1699	1734	1771	1807	1844	44
17	1490	1524	1559	1593	1628	1664	1699	1735	1771	1808	1844	43
18	1491	1525	1559	1594	1629	1664	1700	1736	1772	1808	1845	42
19	1491	1526	1560	1595	1630	1665	1700	1736	1772	1809	1846	41
20	0.1492	0.1526	0.1561	0.1595	0.1630	0.1665	0.1701	0.1737	0.1773	0.1809	0.1846	40
21	1493	1527	1561	1596	1631	1666	1702	1737	1774	1810	1847	39
22	1493	1527	1562	1596	1631	1667	1702	1738	1774	1811	1847	38
23	1494	1528	1562	1597	1632	1667	1703	1739	1775	1811	1848	37
24	1494	1528	1563	1598	1633	1668	1703	1739	1775	1812	1849	36
25	0.1495	0.1529	0.1563	0.1598	0.1633	0.1668	0.1704	0.1740	0.1776	0.1812	0.1849	35
26	1495	1530	1564	1599	1634	1669	1705	1740	1777	1813	1850	34
27	1496	1530	1565	1599	1634	1670	1705	1741	1777	1814	1850	33
28	1496	1531	1565	1600	1635	1670	1706	1742	1778	1814	1851	32
29	1497	1531	1566	1600	1635	1671	1706	1742	1778	1815	1852	31
30	0.1498	0.1532	0.1566	0.1601	0.1636	0.1671	0.1707	0.1743	0.1779	0.1816	0.1852	30
31	1498	1532	1567	1602	1637	1672	1708	1743	1780	1816	1853	29
32	1499	1533	1567	1602	1637	1673	1708	1744	1780	1817	1854	28
33	1499	1534	1568	1603	1638	1673	1709	1745	1781	1817	1854	27
34	1500	1534	1569	1603	1638	1674	1709	1745	1781	1818	1855	26
35	0.1500	0.1535	0.1569	0.1604	0.1639	0.1674	0.1710	0.1746	0.1782	0.1819	0.1855	25
36	1501	1535	1570	1605	1640	1675	1711	1746	1783	1819	1856	24
37	1502	1536	1570	1605	1640	1676	1711	1747	1783	1820	1857	23
38	1502	1536	1571	1606	·641	1676	1712	1748	1784	1820	1857	22
39	1503	1537	1571	1606	1641	1677	1712	1748	1785	1821	1858	21
40	0 1503	0.1538	0.1572	0.1607	0.1642	0.1677	0.1713	0.1749	0.1785	0.1822	0.1859	20
41	1504	1538	1573	1607	1643	1678	1714	1749	1786	1822	1859	19
42	1504	1539	1573	1608	1643	1678	1714	1750	1786	1823	1860	18
43	1505	1539	1574	1609	1644	1679	1715	1751	1787	1823	1860	17
44	1506	1540	1574	1609	1644	1680	1715	1751	1788	1824	1861	16
45	0.1506	0 1540	0.1575	0.1610	0.1645	0.1680	0.1716	0.1752	0.1788	0.1825	0.1862	15
46	1507	1541	1576	1610	1645	1681	1717	1752	1789	1825	1862	14
47	1507	1542	1576	1611	1646	1681	1717	1753	1789	1826	1863	13
48	1508	1542	1577	1612	1647	1682	1718	1754	1790	1827	1863	12
49	1508	1543	1577	1612	1647	1683	1718	1754	1791	1827	1864	11
50	0.1509	0 1543	0.1578	0.1613	0.1648	0.1683	0.1719	0.1755	0.1791	0.1828	0.1865	10
51	1510	1544	1578	1613	1648	1684	1719	1755	1792	1828	1865	9
52	1510	1544	1579	1614	1649	1684	1720	1756	1792	1829	1866	8
53	1511	1545	1580	1614	1650	1685	1721	1757	1793	1830	1867	7
54	1511	1546	1580	1615	1650	1686	1721	1757	1794	1830	1867	6
55	0.15·2	0.1546	0.1581	0.1616	0.1651	0.1686	0.1722	0.1758	0.1794	0.1831	0.1868	5
56	1512	1547	1581	1616	1651	1687	1722	1759	1795	1831	1868	4
57	1513	1547	1582	1617	1652	1687	1723	1759	1795	1832	1869	3
58	1514	1548	1582	1617	1652	1688	1724	1760	1796	1833	1870	2
59	1514	1548	1583	1618	1653	1689	1724	1760	1797	1833	1870	1
60	1515	1549	1584	1619	1654	1689	1725	1761	1797	1834	1871	0
	7° 7′	7° 6′	7° 5′	7° 4′	7° 3′	7° 2′	7° 1′	7° 0′	6° 59′	6° 58′	6° 57′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

TABLE XLVII.

The *first* correction is always to be taken at the *top*.
The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

"	3° 3'	3° 4'	3° 5'	3° 6'	3° 7'	3° 8'	3° 9'	3° 10'	3° 11'	3° 12'	3° 13'	
0	0.1871	0.1908	0.1946	0.1984	0.2022	0.2061	0.2099	0.2139	0.2178	0.2218	0.2259	60
1	1871	1909	1946	1984	2023	2061	2100	2139	2179	2219	2260	59
2	1872	1909	1947	1985	2023	2062	2101	2140	2180	2220	2260	58
3	1873	1910	1948	1986	2024	2062	2101	2141	2180	2220	2261	57
4	1873	1911	1948	1986	2025	2063	2102	2141	2181	2221	2262	56
5	0.1874	0.1911	0.1949	0.1987	0.2025	0.2064	0.2103	0.2142	0.2182	0.2222	0.2262	55
6	1875	1912	1950	1987	2026	2064	2103	2143	2182	2223	2263	54
7	1875	1913	1950	1988	2026	2065	2104	2143	2183	2223	2264	53
8	1876	1913	1951	1989	2027	2066	2105	2144	2184	2224	2264	52
9	1876	1914	1951	1989	2028	2066	2105	2145	2184	2225	2265	51
10	0.1877	0.1914	0.1952	0.1990	0.2028	0.2067	0.2106	0.2145	0.2185	0.2225	0.2266	50
11	1878	1915	1953	1991	2029	2068	2107	2146	2186	2226	2266	49
12	1878	1916	1953	1991	2030	2068	2107	2147	2186	2227	2267	48
13	1879	1916	1954	1992	2030	2069	2108	2147	2187	2227	2268	47
14	1880	1917	1955	1993	2031	2070	2109	2148	2188	2228	2268	46
15	0.1880	0.1918	0.1955	0.1993	0.2032	0.2070	0.2109	0.2149	0.2188	0.2229	0.2269	45
16	1881	1918	1956	1994	2032	2071	2110	2149	2189	2229	2270	44
17	1881	1919	1956	1994	2033	2072	2111	2150	2190	2230	2270	43
18	1882	1919	1957	1995	2033	2072	2111	2151	2190	2231	2271	42
19	1883	1920	1958	1996	2034	2073	2112	2151	2191	2231	2272	41
20	0.1883	0.1921	0.1958	0.1996	0.2035	0.2073	0.2113	0.2152	0.2192	0.2232	0.2272	40
21	1884	1921	1959	1997	2035	2074	2113	2153	2192	2233	2273	39
22	1884	1922	1960	1998	2036	2075	2114	2153	2193	2233	2274	38
23	1885	1923	1960	1998	2037	2075	2115	2154	2194	2234	2274	37
24	1886	1923	1961	1999	2037	2076	2115	2155	2194	2235	2275	36
25	0.1886	0.1924	0.1962	0.2000	0.2038	0.2077	0.2116	0.2155	0.2195	0.2235	0.2276	35
26	1887	1924	1962	2000	2039	2077	2116	2156	2196	2236	2277	34
27	1888	1925	1963	2001	2039	2078	2117	2157	2196	2237	2277	33
28	1888	1926	1963	2001	2040	2079	2118	2157	2197	2237	2278	32
29	1889	1926	1964	2002	2041	2079	2118	2158	2198	2238	2279	31
30	0.1889	0.1927	0.1965	0.2003	0.2041	0.2080	0.2119	0.2159	0.2198	0.2239	0.2279	30
31	1890	1928	1965	2003	2042	2081	2120	2159	2199	2239	2280	29
32	1891	1928	1966	2004	2042	2081	2120	2160	2200	2240	2281	28
33	1891	1929	1967	2005	2043	2082	2121	2161	2200	2241	2281	27
34	1892	1929	1967	2005	2044	2083	2122	2161	2201	2241	2282	26
35	0.1893	0.1930	0.1968	0.2006	0.2044	0.2083	0.2122	0.2162	0.2202	0.2242	0.2283	25
36	1893	1931	1968	2007	2045	2084	2123	2163	2202	2243	2283	24
37	1894	1931	1969	2007	2046	2085	2124	2163	2203	2243	2284	23
38	1894	1932	1970	2008	2046	2085	2124	2164	2204	2244	2285	22
39	1895	1933	1970	2009	2047	2086	2125	2165	2204	2245	2285	21
40	0.1896	0.1933	0.1971	0.2009	0.2048	0.2086	0.2126	0.2165	0.2205	0.2245	0.2286	20
41	1896	1934	1972	2010	2048	2087	2126	2166	2206	2246	2287	19
42	1897	1934	1972	2010	2049	2088	2127	2167	2206	2247	2287	18
43	1898	1935	1973	2011	2050	2088	2128	2167	2207	2247	2288	17
44	1898	1936	1974	2012	2050	2089	2128	2168	2208	2248	2289	16
45	0.1899	0.1936	0.1974	0.2012	0.2051	0.2090	0.2129	0.2169	0.2208	0.2249	0.2289	15
46	1899	1937	1975	2013	2052	2090	2130	2169	2209	2249	2290	14
47	1900	1938	1975	2014	2052	2091	2130	2170	2210	2250	2291	13
48	1901	1938	1976	2014	2053	2092	2131	2170	2210	2251	2291	12
49	1901	1939	1977	2015	2053	2092	2132	2171	2211	2251	2292	11
50	0.1902	0.1939	0.1977	0.2016	0.2054	0.2093	0.2132	0.2172	0.2212	0.2252	0.2293	10
51	1903	1940	1978	2016	2055	2094	2133	2172	2212	2253	2294	9
52	1903	1941	1979	2017	2055	2094	2134	2173	2213	2253	2294	8
53	1904	1941	1979	2017	2056	2095	2134	2174	2214	2254	2295	7
54	1904	1942	1980	2018	2057	2096	2135	2174	2214	2255	2296	6
55	0.1905	0.1943	0.1981	0.2019	0.2057	0.2096	0.2136	0.2175	0.2215	0.2256	0.2296	5
56	1906	1943	1981	2019	2058	2097	2136	2176	2216	2256	2297	4
57	1906	1944	1982	2020	2059	2098	2137	2176	2216	2257	2298	3
58	1907	1944	1982	2021	2059	2098	2137	2177	2217	2258	2298	2
59	1908	1945	1983	2021	2060	2099	2138	2178	2218	2258	2299	1
60	1908	1946	1984	2022	2061	2099	2139	2178	2218	2259	2300	0
	6° 56'	6° 55'	6° 54'	6° 53'	6° 52'	6° 51'	6° 50'	6° 49'	6° 48'	6° 47'	6° 46'	"

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	3° 14′	3° 15′	3° 16′	3° 17′	3° 18′	3° 19′	3° 20′	3° 21′	3° 22′	3° 23′	3° 24′	
0	0.2300	0.2341	0.2382	0.2424	0.2467	0.2510	0.2553	0.2596	0.2640	0.2685	0.2730	60
1	2300	2342	2383	2425	2467	2510	2553	2597	2641	2686	2731	59
2	2301	2342	2384	2426	2468	2511	2554	2598	2642	2687	2732	58
3	2302	2343	2384	2426	2469	2512	2555	2599	2643	2687	2732	57
4	2302	2344	2385	2427	2470	2512	2556	2599	2643	2688	2733	56
5	0.2303	0.2344	0.2386	0.2428	0.2470	0.2513	0.2556	0.2600	0.2644	0.2689	0.2734	55
6	2304	2345	2387	2429	2471	2514	2557	2601	2645	2689	2735	54
7	2304	2346	2387	2429	2472	2515	2558	2601	2646	2690	2735	53
8	2305	2346	2388	2430	2472	2515	2559	2602	2646	2691	2736	52
9	2306	2347	2389	2431	2473	2516	2559	2603	2647	2692	2737	51
10	0.2307	0.2348	0.2389	0.2431	0.2474	0.2517	0.2560	0.2604	0.2648	0.2692	0.2738	50
11	2307	2348	2390	2432	2475	2517	2561	2604	2649	2693	2738	49
12	2308	2349	2391	2433	2475	2518	2561	2605	2649	2694	2739	48
13	2309	2350	2391	2433	2476	2519	2562	2606	2650	2695	2740	47
14	2309	2350	2392	2434	2477	2520	2563	2607	2651	2695	2741	46
15	0.2310	0.2351	0.2393	0.2435	0.2477	0.2520	0.2564	0.2607	0.2652	0.2696	0.2741	45
16	2311	2352	2394	2436	2478	2521	2564	2608	2652	2697	2742	44
17	2311	2353	2394	2436	2479	2522	2565	2609	2653	2698	2743	43
18	2312	2353	2395	2437	2480	2522	2566	2610	2654	2698	2744	42
19	2313	2354	2396	2438	2480	2523	2566	2610	2655	2699	2744	41
20	0.2313	0.2355	0.2396	0.2438	0.2481	0.2524	0.2567	0.2611	0.2655	0.2700	0.2745	40
21	2314	2355	2397	2439	2482	2525	2568	2612	2656	2701	2746	39
22	2315	2356	2398	2440	2482	2525	2569	2612	2657	2701	2747	38
23	2315	2357	2398	2441	2483	2526	2569	2613	2657	2702	2747	37
24	2316	2357	2399	2441	2484	2527	2570	2614	2658	2703	2748	36
25	0.2317	0.2358	0.2400	0.2442	0.2485	0.2527	0.2571	0.2615	0.2659	0.2704	0.2749	35
26	2317	2359	2401	2443	2485	2528	2572	2615	2660	2704	2750	34
27	2318	2359	2401	2443	2486	2529	2572	2616	2660	2705	2750	33
28	2319	2360	2402	2444	2487	2530	2573	2617	2661	2706	2751	32
29	2320	2361	2403	2445	2487	2530	2574	2618	2662	2707	2752	31
30	0.2320	0.2362	0.2403	0.2445	0.2488	0.2531	0.2574	0.2618	0.2663	0.2707	0.2753	30
31	2321	2362	2404	2446	2489	2532	2575	2619	2663	2708	2753	29
32	2322	2363	2405	2447	2489	2533	2576	2620	2664	2709	2754	28
33	2322	2364	2405	2448	2490	2533	2577	2621	2665	2710	2755	27
34	2323	2364	2406	2448	2491	2534	2577	2621	2666	2710	2756	26
35	0.2324	0.2365	0.2407	0.2449	0.2492	0.2535	0.2578	0.2622	0.2666	0.2711	0.2756	25
36	2324	2366	2408	2450	2492	2535	2579	2623	2667	2712	2757	24
37	2325	2366	2408	2450	2493	2536	2580	2624	2668	2713	2758	23
38	2326	2367	2409	2451	2494	2537	2580	2624	2669	2713	2759	22
39	2326	2368	2410	2452	2494	2538	2581	2625	2669	2714	2760	21
40	0.2327	0.2368	0.2410	0.2453	0.2495	0.2538	0.2582	0.2626	0.2670	0.2715	0.2760	20
41	2328	2369	2411	2453	2496	2539	2583	2626	2671	2716	2761	19
42	2328	2370	2412	2454	2497	2540	2583	2627	2672	2716	2762	18
43	2329	2371	2412	2455	2497	2540	2584	2628	2672	2717	2763	17
44	2330	2371	2413	2455	2498	2541	2585	2629	2673	2718	2763	16
45	0.2331	0.2372	0.2414	0.2456	0.2499	0.2542	0.2585	0.2629	0.2674	0.2719	0.2764	15
46	2331	2373	2415	2457	2499	2543	2586	2630	2675	2719	2765	14
47	2332	2373	2415	2458	2500	2543	2587	2631	2675	2720	2766	13
48	2333	2374	2416	2458	2501	2544	2588	2632	2676	2721	2766	12
49	2333	2375	2417	2459	2502	2545	2588	2632	2677	2722	2767	11
50	0.2334	0.2375	0.2417	0.2460	0.2502	0.2545	0.2589	0.2633	0.2678	0.2722	0.2768	10
51	2335	2376	2418	2460	2503	2546	2590	2634	2678	2723	2769	9
52	2335	2377	2419	2461	2504	2547	2591	2635	2679	2724	2769	8
53	2336	2378	2419	2462	2504	2548	2591	2635	2680	2725	2770	7
54	2337	2378	2420	2462	2505	2548	2592	2636	2681	2725	2771	6
55	0.2337	0.2379	0.2421	0.2463	0.2506	0.2549	0.2593	0.2637	0.2681	0.2726	0.2772	5
56	2338	2380	2422	2464	2507	2550	2593	2638	2682	2727	2772	4
57	2339	2380	2422	2465	2507	2551	2594	2638	2683	2728	2773	3
58	2339	2381	2423	2465	2508	2551	2595	2639	2684	2729	2774	2
59	2340	2382	2424	2466	2509	2552	2596	2640	2684	2729	2775	1
60	2341	2382	2424	2467	2510	2553	2596	2640	2685	2730	2775	0
	6° 45′	6° 44′	6° 43′	6° 42′	6° 41′	6° 40′	6° 39′	6° 38′	6° 37′	6° 36′	6° 35′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	3° 25′	3° 26′	3° 27′	3° 28′	3° 29′	3° 30′	3° 31′	3° 32′	3° 33′	3° 34′	3° 35′	
0	0.2775	0.2821	0.2868	0.2915	0.2962	0.3010	0.3059	0.3108	0.3158	0.3208	0.3259	60
1	2776	2822	2869	2916	2963	3011	3060	3109	3158	3209	3259	59
2	2777	2823	2869	2916	2964	3012	3060	3110	3159	3209	3260	58
3	2778	2824	2870	2917	2965	3013	3061	3110	3160	3210	3261	57
4	2779	2825	2871	2918	2965	3014	3062	3111	3161	3211	3262	56
5	0.2779	0.2825	0.2872	0.2919	0.2966	0.3014	0.3063	0.3112	0.3162	0.3212	0.3263	55
6	2780	2826	2873	2920	2967	3015	3064	3113	3163	3213	3264	54
7	2781	2827	2873	2920	2968	3016	3065	3114	3163	3214	3265	53
8	2782	2828	2874	2921	2969	3017	3065	3114	3164	3214	3265	52
9	2782	2828	2875	2922	2969	3018	3066	3115	3165	3215	3266	51
10	0.2783	0.2829	0.2876	0.2923	0.2970	0.3018	0.3067	0.3116	0.3166	0.3216	0.3267	50
11	2784	2830	2876	2924	2971	3019	3068	3117	3167	3217	3268	49
12	2785	2831	2877	2924	2972	3020	3069	3118	3168	3218	3269	48
13	2785	2831	2878	2925	2973	3021	3069	3119	3168	3219	3270	47
14	2786	2832	2879	2926	2973	3022	3070	3119	3169	3220	3270	46
15	0.2787	0.2833	0.2880	0.2927	0.2974	0.3022	0.3071	0.3120	0.3170	0.3220	0.3271	45
16	2788	2834	2880	2927	2975	3023	3072	3121	3171	3221	3272	44
17	2788	2835	2881	2928	2976	3024	3073	3122	3172	3222	3273	43
18	2789	2835	2882	2929	2977	3025	3073	3123	3173	3223	3274	42
19	2790	2836	2883	2930	2977	3026	3074	3124	3173	3224	3275	41
20	0.2791	0.2837	0.2883	0.2931	0.2978	0.3026	0.3075	0.3124	0.3174	0.3225	0.3276	40
21	2792	2838	2884	2931	2979	3027	3076	3125	3175	3225	3276	39
22	2792	2838	2885	2932	2980	3028	3077	3126	3176	3226	3277	38
23	2793	2839	2886	2933	2981	3029	3078	3127	3177	3227	3278	37
24	2794	2840	2887	2934	2981	3030	3078	3128	3178	3228	3279	36
25	0.2795	0.2841	0.2887	0.2935	0.2982	0.3030	0.3079	0.3129	0.3178	0.3229	0.3280	35
26	2795	2842	2888	2935	2983	3031	3080	3129	3179	3230	3281	34
27	2796	2842	2889	2936	2984	3032	3081	3130	3180	3231	3282	33
28	2797	2843	2890	2937	2985	3033	3082	3131	3181	3231	3282	32
29	2798	2844	2891	2938	2985	3034	3082	3132	3182	3232	3283	31
30	0.2798	0.2845	0.2891	0.2939	0.2986	0.3034	0.3083	0.3133	0.3183	0.3233	0.3284	30
31	2799	2845	2892	2939	2987	3035	3084	3133	3183	3234	3285	29
32	2800	2846	2893	2940	2988	3036	3085	3134	3184	3235	3286	28
33	2801	2847	2894	2941	2989	3037	3086	3135	3185	3236	3287	27
34	2801	2848	2894	2942	2989	3038	3087	3136	3186	3236	3288	26
35	0.2802	0.2848	0.2895	0.2942	0.2990	0.3039	0.3087	0.3137	0.3187	0.3237	0.3288	25
36	2803	2849	2896	2943	2991	3039	3088	3138	3188	3238	3289	24
37	2804	2850	2897	2944	2992	3040	3089	3138	3188	3239	3290	23
38	2805	2851	2898	2945	2993	3041	3090	3139	3189	3240	3291	22
39	2805	2852	2898	2946	2993	3042	3091	3140	3190	3241	3292	21
40	0.2806	0.2852	0.2899	0.2946	0.2994	0.3043	0.3091	0.3141	0.3191	0.3242	0.3293	20
41	2807	2853	2900	2947	2995	3043	3092	3142	3192	3242	3294	19
42	2808	2854	2901	2948	2996	3044	3093	3143	3193	3243	3294	18
43	2808	2855	2901	2949	2997	3045	3094	3143	3193	3244	3295	17
44	2809	2855	2902	2950	2997	3046	3095	3144	3194	3245	3296	16
45	0.2810	0.2856	0.2903	0.2950	0.2998	0.3047	0.3096	0.3145	0.3195	0.3246	0.3297	15
46	2811	2857	2904	2951	2999	3047	3096	3146	3196	3247	3298	14
47	2811	2858	2905	2952	3000	3048	3097	3147	3197	3247	3299	13
48	2812	2859	2905	2953	3001	3049	3098	3148	3198	3248	3300	12
49	2813	2859	2906	2954	3001	3050	3099	3148	3198	3249	3300	11
50	0.2814	0.2860	0.2907	0.2954	0.3002	0.3051	0.3100	0.3149	0.3199	0.3250	0.3301	10
51	2815	2861	2908	2955	3003	3052	3101	3150	3200	3251	3302	9
52	2815	2862	2909	2956	3004	3052	3101	3151	3201	3252	3303	8
53	2816	2862	2909	2957	3005	3053	3102	3152	3202	3253	3304	7
54	2817	2863	2910	2958	3005	3054	3103	3153	3203	3253	3305	6
55	0.2818	0.2864	0.2911	0.2958	0.3006	0.3055	0.3104	0.3153	0.3204	0.3254	0.3306	5
56	2818	2865	2912	2959	3007	3056	3105	3154	3204	3255	3306	4
57	2819	2866	2912	2960	3008	3056	3105	3155	3205	3256	3307	3
58	2820	2866	2913	2961	3009	3057	3106	3156	3206	3257	3308	2
59	2821	2867	2914	2962	3009	3058	3107	3157	3207	3258	3309	1
60	2821	2868	2915	2962	3010	3059	3108	3158	3208	3259	3310	0
	6° 34′	6° 33′	6° 32′	6° 31′	6° 30′	6° 29′	6° 28′	6° 27′	6° 26′	6° 25′	6° 24′	′

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.
The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	3° 36′	3° 37′	3° 38′	3° 39′	3° 40′	3° 41′	3° 42′	3° 43′	3° 44′	3° 45′	3° 46′	
0	0.3310	0.3362	0.3415	0.3468	0.3522	0.3576	0.3632	0.3688	0.3745	0.3802	0.3860	60
1	3311	3363	3415	3469	3523	3577	3633	3689	3746	3803	3861	59
2	3312	3364	3416	3470	3524	3578	3634	3690	3746	3804	3862	58
3	3313	3365	3417	3471	3525	3579	3635	3691	3747	3805	3863	57
4	3313	3365	3418	3471	3525	3580	3635	3692	3748	3806	3864	56
5	0.3314	0.3366	0.3419	0.3472	0.3526	0.3581	0.3636	0.3693	0.3749	0.3807	0.3865	55
6	3315	3367	3420	3473	3527	3582	3637	3693	3750	3808	3866	54
7	3316	3368	3421	3474	3528	3583	3638	3694	3751	3809	3867	53
8	3317	3369	3422	3475	3529	3584	3639	3695	3752	3810	3868	52
9	3318	3370	3423	3476	3530	3585	3640	3696	3753	3811	3869	51
10	0.3319	0.3371	0.3423	0.3477	0.3531	0.3586	0.3641	0.3697	0.3754	0.3812	0.3870	50
11	3319	3372	3424	3478	3532	3587	3642	3698	3755	3813	3871	49
12	3320	3372	3425	3479	3533	3587	3643	3699	3756	3814	3872	48
13	3321	3373	3426	3480	3534	3588	3644	3700	3757	3815	3873	47
14	3322	3374	3427	3480	3535	3589	3645	3701	3758	3816	3874	46
15	0.3323	0.3375	0.3428	0.3481	0.3535	0.3590	0.3646	0.3702	0.3759	0.3817	0.3875	45
16	3324	3376	3429	3482	3536	3591	3647	3703	3760	3818	3876	44
17	3325	3377	3430	3483	3537	3592	3648	3704	3761	3819	3877	43
18	3325	3378	3431	3484	3538	3593	3649	3705	3762	3820	3878	42
19	3326	3379	3431	3485	3539	3594	3649	3706	3763	3820	3879	41
20	0.3327	0.3379	0.3432	0.3486	0.3540	0.3595	0.3650	0.3707	0.3764	0.3821	0.3880	40
21	3328	3380	3433	3487	3541	3596	3651	3708	3765	3822	3881	39
22	3329	3381	3434	3488	3542	3597	3652	3709	3766	3823	3882	38
23	3330	3382	3435	3488	3543	3598	3653	3709	3767	3824	3883	37
24	3331	3383	3436	3489	3544	3598	3654	3710	3768	3825	3884	36
25	0.3332	0.3384	0.3437	0.3490	0.3545	0.3599	0.3655	0.3711	0.3768	0.3826	0.3885	35
26	3332	3385	3438	3491	3545	3600	3656	3712	3769	3827	3886	34
27	3333	3386	3438	3492	3546	3601	3657	3713	3770	3828	3887	33
28	3334	3386	3439	3493	3547	3602	3658	3714	3771	3829	3888	32
29	3335	3387	3440	3494	3548	3603	3659	3715	3772	3830	3889	31
30	0.3336	0.3388	0.3441	0.3495	0.3549	0.3604	0.3660	0.3716	0.3773	0.3831	0.3890	30
31	3337	3389	3442	3496	3550	3605	3661	3717	3774	3832	3891	29
32	3338	3390	3443	3497	3551	3606	3662	3718	3775	3833	3892	28
33	3338	3391	3444	3497	3552	3607	3663	3719	3776	3834	3893	27
34	3339	3392	3445	3498	3553	3608	3663	3720	3777	3835	3894	26
35	0.3340	0.3393	0.3446	0.3499	0.3554	0.3609	0.3664	0.3721	0.3778	0.3836	0.3895	25
36	3341	3393	3446	3500	3555	3610	3665	3722	3779	3837	3896	24
37	3342	3394	3447	3501	3555	3610	3666	3723	3780	3838	3897	23
38	3343	3395	3448	3502	3556	3611	3667	3724	3781	3839	3898	22
39	3344	3396	3449	3503	3557	3612	3668	3725	3782	3840	3899	21
40	0.3345	0.3397	0.3450	0.3504	0.3558	0.3613	0.3669	0.3726	0.3783	0.3841	0.3900	20
41	3345	3398	3451	3505	3559	3614	3670	3727	3784	3842	3901	19
42	3346	3399	3452	3506	3560	3615	3671	3727	3785	3843	3902	18
43	3347	3400	3453	3506	3561	3616	3672	3728	3786	3844	3903	17
44	3348	3400	3454	3507	3562	3617	3673	3729	3787	3845	3904	16
45	0.3349	0.3401	0.3454	0.3508	0.3563	0.3618	0.3674	0.3730	0.3788	0.3846	0.3905	15
46	3350	3402	3455	3509	3564	3619	3675	3731	3789	3847	3906	14
47	3351	3403	3456	3510	3565	3620	3676	3732	3790	3848	3907	13
48	3351	3404	3457	3511	3565	3621	3677	3733	3791	3849	3908	12
49	3352	3405	3458	3512	3566	3622	3677	3734	3792	3850	3909	11
50	0.3353	0.3406	0.3459	0.3513	0.3567	0.3623	0.3678	0.3735	0.3792	0.3851	0.3910	10
51	3354	3407	3460	3514	3568	3623	3679	3736	3793	3852	3911	9
52	3355	3408	3461	3515	3569	3624	3680	3737	3794	3853	3912	8
53	3356	3408	3462	3515	3570	3625	3681	3738	3795	3854	3913	7
54	3357	3409	3463	3516	3571	3626	3682	3739	3796	3855	3914	6
55	0.3358	0.3410	0.3463	0.3517	0.3572	0.3627	0.3683	0.3740	0.3797	0.3856	0.3915	5
56	3358	3411	3464	3518	3573	3628	3684	3741	3798	3856	3916	4
57	3359	3412	3465	3519	3574	3629	3685	3742	3799	3857	3917	3
58	3360	3413	3466	3520	3575	3630	3686	3743	3800	3858	3918	2
59	3361	3414	3467	3521	3576	3631	3687	3744	3801	3859	3919	1
60	3362	3415	3468	3522	3576	3632	3688	3745	3802	3860	3919	0
	6° 23′	6° 22′	6° 21′	6° 20′	6° 19′	6° 18′	6° 17′	6° 16′	6° 15′	6° 14′	6° 13′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	3° 47′	3° 48′	3° 49′	3° 50′	3° 51′	3° 52′	3° 53′	3° 54′	3° 55′	3° 56′	3° 57′	
0	0.3919	0.3979	0.4040	0.4102	0.4164	0.4228	0.4292	0.4357	0.4424	0.4491	0.4559	60
1	3920	3980	4041	4103	4165	4229	4293	4358	4425	4492	4560	59
2	3921	3981	4042	4104	4166	4230	4294	4359	4426	4493	4562	58
3	3922	3982	4043	4105	4167	4231	4295	4361	4427	4494	4563	57
4	3923	3983	4044	4106	4168	4232	4296	4362	4428	4495	4564	56
5	0.3924	0.3984	0.4045	0.4107	0.4169	0.4233	0.4297	0.4363	0.4429	0.4497	0.4565	55
6	3925	3985	4046	4108	4171	4234	4298	4364	4430	4498	4566	54
7	3926	3986	4047	4109	4172	4235	4300	4365	4431	4499	4567	53
8	3927	3987	4048	4110	4173	4236	4301	4366	4433	4500	4569	52
9	3928	3988	4049	4111	4174	4237	4302	4367	4434	4501	4570	51
10	0.3929	0.3989	0.4050	0.4112	0.4175	0.4238	0.4303	0.4368	0.4435	0.4502	0.4571	50
11	3930	3990	4051	4113	4176	4239	4304	4369	4436	4503	4572	49
12	3931	3991	4052	4114	4177	4240	4305	4370	4437	4505	4573	48
13	3932	3992	4053	4115	4178	4241	4306	4372	4438	4506	4574	47
14	3933	3993	4054	4116	4179	4243	4307	4373	4439	4507	4575	46
15	0.3934	0.3995	0.4055	0.4117	0.4180	0.4244	0.4308	0.4374	0.4440	0.4508	0.4577	45
16	3935	3996	4056	4118	4181	4245	4309	4375	4441	4509	4578	44
17	3936	3997	4058	4119	4182	4246	4310	4376	4443	4510	4579	43
18	3937	3998	4059	4120	4183	4247	4311	4377	4444	4511	4580	42
19	3938	3999	4060	4121	4184	4248	4313	4378	4445	4512	4581	41
20	0.3939	0.4000	0.4061	0.4122	0.4185	0.4249	0.4314	0.4379	0.4446	0.4514	0.4582	40
21	3940	4001	4062	4124	4186	4250	4315	4380	4447	4515	4584	39
22	3941	4002	4063	4125	4187	4251	4316	4381	4448	4516	4585	38
23	3942	4003	4064	4126	4188	4252	4317	4383	4449	4517	4586	37
24	3943	4004	4065	4127	4189	4253	4318	4384	4450	4518	4587	36
25	0.3944	0.4005	0.4066	0.4128	0.4191	0.4254	0.4319	0.4385	0.4452	0.4519	0.4588	35
26	3945	4006	4067	4129	4192	4255	4320	4386	4453	4520	4589	34
27	3946	4007	4068	4130	4193	4256	4321	4387	4454	4522	4590	33
28	3947	4008	4069	4131	4194	4258	4322	4388	4455	4523	4592	32
29	3948	4009	4070	4132	4195	4259	4323	4389	4456	4524	4593	31
30	0.3949	0.4010	0.4071	0.4133	0.4196	0.4260	0.4325	0.4390	0.4457	0.4525	0.4594	30
31	3950	4011	4072	4134	4197	4261	4326	4391	4458	4526	4595	29
32	3951	4012	4073	4135	4198	4262	4327	4393	4459	4527	4596	28
33	3952	4013	4074	4136	4199	4263	4328	4394	4460	4528	4597	27
34	3953	4014	4075	4137	4200	4264	4329	4395	4462	4530	4599	26
35	0.3954	0.4015	0.4076	0.4138	0.4201	0.4265	0.4330	0.4396	0.4463	0.4531	0.4600	25
36	3955	4016	4077	4139	4202	4266	4331	4397	4464	4532	4601	24
37	3956	4017	4078	4140	4203	4267	4332	4398	4465	4533	4602	23
38	3957	4018	4079	4141	4204	4268	4333	4399	4466	4534	4603	22
39	3958	4019	4080	4142	4205	4269	4334	4400	4467	4535	4604	21
40	0.3959	0.4020	0.4081	0.4143	0.4206	0.4270	0.4335	0.4401	0.4468	0.4536	0.4606	20
41	3960	4021	4082	4144	4207	4271	4336	4402	4469	4538	4607	19
42	3961	4022	4083	4145	4209	4273	4338	4404	4471	4539	4608	18
43	3962	4023	4084	4146	4210	4274	4339	4405	4472	4540	4609	17
44	3963	4024	4085	4147	4211	4275	4340	4406	4473	4541	4610	16
45	0.3964	0.4025	0.4086	0.4149	0.4212	0.4276	0.4341	0.4407	0.4474	0.4542	0.4611	15
46	3965	4026	4087	4150	4213	4277	4342	4408	4475	4543	4612	14
47	3966	4027	4088	4151	4214	4278	4343	4409	4476	4544	4614	13
48	3967	4028	4089	4152	4215	4279	4344	4410	4477	4546	4615	12
49	3968	4029	4090	4153	4216	4280	4345	4411	4479	4547	4616	11
50	0.3969	0.4030	0.4091	0.4154	0.4217	0.4281	0.4346	0.4412	0.4480	0.4548	0.4617	10
51	3970	4031	4092	4155	4218	4282	4347	4414	4481	4549	4618	9
52	3971	4032	4093	4156	4219	4283	4349	4415	4482	4550	4619	8
53	3972	4033	4095	4157	4220	4284	4350	4416	4483	4551	4621	7
54	3973	4034	4096	4158	4221	4285	4351	4417	4484	4552	4622	6
55	0.3974	0.4035	0.4097	0.4159	0.4222	0.4287	0.4352	0.4418	0.4485	0.4554	0.4623	5
56	3975	4036	4098	4160	4223	4288	4353	4419	4486	4555	4624	4
57	3976	4037	4099	4161	4224	4289	4354	4420	4488	4556	4625	3
58	3977	4038	4100	4162	4226	4290	4355	4421	4489	4557	4626	2
59	3978	4039	4101	4163	4227	4291	4356	4422	4490	4558	4628	1
60	3979	4040	4102	4164	4228	4292	4357	4424	4491	4559	4629	0
	6° 12′	6° 11′	6° 10′	6° 9′	6° 8′	6° 7′	6° 6′	6° 5′	6° 4′	6° 3′	6° 2′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.
The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

"	3° 58′	3° 59′	4° 0′	4° 1′	4° 2′	4° 3′	4° 4′	4° 5′	4° 6′	4° 7′	4° 8′	
0	0.4629	0.4699	0.4771	0.4844	0.4918	0.4994	0.5071	0.5149	0.5229	0.5310	0.5393	60
1	4630	4701	4772	4845	4920	4995	5072	5150	5230	5311	5394	59
2	4631	4702	4774	4847	4921	4997	5073	5152	5231	5313	5395	58
3	4632	4703	4775	4848	4922	4998	5075	5153	5233	5314	5397	57
4	4633	4704	4776	4849	4923	4999	5076	5154	5234	5315	5398	56
5	0.4635	0.4705	0.4777	0.4850	0.4925	0.5000	0.5077	0.5156	0.5235	0.5317	0.5400	55
6	4636	4707	4778	4852	4926	5002	5079	5157	5237	5318	5401	54
7	4637	4708	4780	4853	4927	5003	5080	5158	5238	5320	5402	53
8	4638	4709	4781	4854	4928	5004	5081	5160	5240	5321	5404	52
9	4639	4710	4782	4855	4930	5005	5082	5161	5241	5322	5405	51
10	0.4640	0.4711	0.4783	0.4856	0.4931	0.5007	0.5084	0.5162	0.5242	0.5324	0.5407	50
11	4642	4712	4785	4858	4932	5008	5085	5164	5244	5325	5408	49
12	4643	4714	4786	4859	4933	5009	5086	5165	5245	5326	5409	48
13	4644	4715	4787	4860	4935	5011	5088	5166	5246	5328	5411	47
14	4645	4716	4788	4861	4936	5012	5089	5168	5248	5329	5412	46
15	0.4646	0.4717	0.4789	0.4863	0.4937	0.5013	0.5090	0.5169	0.5249	0.5331	0.5414	45
16	4648	4718	4791	4864	4938	5014	5092	5170	5250	5332	5415	44
17	4649	4720	4792	4865	4940	5016	5093	5172	5252	5333	5416	43
18	4650	4721	4793	4866	4941	5017	5094	5173	5253	5335	5418	42
19	4651	4722	4794	4868	4942	5018	5095	5174	5254	5336	5419	41
20	0.4652	0.4723	0.4795	0.4869	0.4943	0.5019	0.5097	0.5175	0.5256	0.5337	0.5421	40
21	4653	4724	4797	4870	4945	5021	5098	5177	5257	5339	5422	39
22	4655	4726	4798	4871	4946	5022	5099	5178	5258	5340	5423	38
23	4656	4727	4799	4873	4947	5023	5101	5179	5260	5341	5425	37
24	4657	4728	4800	4874	4949	5025	5102	5181	5261	5343	5426	36
25	0.4658	0.4729	0.4801	0.4875	0.4950	0.5026	0.5103	0.5182	0.5262	0.5344	0.5428	35
26	4659	4730	4803	4876	4951	5027	5105	5183	5264	5346	5429	34
27	4660	4732	4804	4877	4952	5028	5106	5185	5265	5347	5430	33
28	4662	4733	4805	4879	4954	5030	5107	5186	5266	5348	5432	32
29	4663	4734	4806	4880	4955	5031	5108	5187	5268	5350	5433	31
30	0.4664	0.4735	0.4808	0.4881	0.4956	0.5032	0.5110	0.5189	0.5269	0.5351	0.5435	30
31	4665	4736	4809	4882	4957	5034	5111	5190	5271	5353	5436	29
32	4666	4738	4810	4884	4959	5035	5112	5191	5272	5354	5437	28
33	4668	4739	4811	4885	4960	5036	5114	5193	5273	5355	5439	27
34	4669	4740	4812	4886	4961	5037	5115	5194	5275	5357	5440	26
35	0.4670	0.4741	0.4814	0.4887	0.4962	0.5039	0.5116	0.5195	0.5276	0.5358	0.5442	25
36	4671	4742	4815	4889	4964	5040	5118	5197	5277	5359	5443	24
37	4672	4744	4816	4890	4965	5041	5119	5198	5279	5361	5445	23
38	4673	4745	4817	4891	4966	5043	5120	5199	5280	5362	5446	22
39	4675	4746	4819	4892	4967	5044	5122	5201	5281	5364	5447	21
40	0.4676	0.4747	0.4820	0.4894	0.4969	0.5045	0.5123	0.5202	0.5283	0.5365	0.5449	20
41	4677	4748	4821	4895	4970	5046	5124	5203	5284	5366	5450	19
42	4678	4750	4822	4896	4971	5048	5125	5205	5285	5368	5452	18
43	4679	4751	4823	4897	4972	5049	5127	5206	5287	5369	5453	17
44	4680	4752	4825	4899	4974	5050	5128	5207	5288	5370	5454	16
45	0.4682	0.4753	0.4826	0.4900	0.4975	0.5051	0.5129	0.5209	0.5290	0.5372	0.5456	15
46	4683	4754	4827	4901	4976	5053	5131	5210	5291	5373	5457	14
47	4684	4756	4828	4902	4977	5054	5132	5211	5292	5375	5459	13
48	4685	4757	4830	4903	4979	5055	5133	5213	5294	5376	5460	12
49	4686	4758	4831	4905	4980	5057	5135	5214	5295	5377	5461	11
50	0.4688	0.4759	0.4832	0.4906	0.4981	0.5058	0.5136	0.5215	0.5296	0.5379	0.5463	10
51	4689	4760	4833	4907	4983	5059	5137	5217	5298	5380	5464	9
52	4690	4762	4834	4908	4984	5061	5139	5218	5299	5382	5466	8
53	4691	4763	4836	4910	4985	5062	5140	5219	5300	5383	5467	7
54	4692	4764	4837	4911	4986	5063	5141	5221	5302	5384	5469	6
55	0.4693	0.4765	0.4838	0.4912	0.4988	0.5064	0.5143	0.5222	0.5303	0.5386	0.5470	5
56	4695	4766	4839	4913	4989	5066	5144	5223	5305	5387	5471	4
57	4696	4768	4841	4915	4990	5067	5145	5225	5306	5389	5473	3
58	4697	4769	4842	4916	4991	5068	5146	5226	5307	5390	5474	2
59	4698	4770	4843	4917	4993	5070	5148	5227	5309	5391	5476	1
60	4699	4771	4844	4918	4994	5071	5149	5229	5310	5393	5477	0
	6° 1′	6° 0′	5° 59′	5° 58′	5° 57′	5° 56′	5° 55′	5° 54′	5° 53′	5° 52′	5° 51′	"

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

"	4° 9′	4° 10′	4° 11′	4° 12′	4° 13′	4° 14′	4° 15′	4° 16′	4° 17′	4° 18′	4° 19′	
0	0.5477	0.5563	0.5651	0.5740	0.5832	0.5925	0.6021	0.6118	0.6218	0.6320	0.6425	60
1	5478	5564	5652	5742	5833	5927	6022	6120	6220	6322	6427	59
2	5480	5566	5654	5743	5835	5928	6024	6121	6221	6324	6428	58
3	5481	5567	5655	5745	5836	5930	6025	6123	6223	6325	6430	57
4	5483	5569	5657	5746	5838	5931	6027	6125	6225	6327	6432	56
5	0.5484	0.5570	0.5658	0.5748	0.5839	0.5933	0.6029	0.6126	0.6226	0.6329	0.6434	55
6	5486	5572	5660	5749	5841	5935	6030	6128	6228	6331	6435	54
7	5487	5573	5661	5751	5843	5936	6032	6130	6230	6332	6437	53
8	5488	5575	5663	5752	5844	5938	6033	6131	6232	6334	6439	52
9	5490	5576	5664	5754	5846	5939	6035	6133	6233	6336	6441	51
10	0.5491	0.5578	0.5666	0.5755	0.5847	0.5941	0.6037	0.6135	0.6235	0.6338	0.6443	50
11	5493	5579	5667	5757	5849	5942	6038	6136	6237	6339	6444	49
12	5494	5580	5669	5758	5850	5944	6040	6138	6238	6341	6446	48
13	5496	5582	5670	5760	5852	5946	6042	6140	6240	6343	6448	47
14	5497	5583	5671	5761	5853	5947	6043	6141	6242	6344	6450	46
15	0.5498	0.5585	0.5673	0.5763	0.5855	0.5949	0.6045	0.6143	0.6243	0.6346	0.6451	45
16	5500	5586	5674	5765	5856	5950	6046	6145	6245	6348	6453	44
17	5501	5588	5676	5766	5858	5952	6048	6146	6247	6350	6455	43
18	5503	5589	5677	5768	5860	5954	6050	6148	6248	6351	6457	42
19	5504	5591	5679	5769	5861	5955	6051	6150	6250	6353	6459	41
20	0.5506	0.5592	0.5680	0.5771	0.5863	0.5957	0.6053	0.6151	0.6252	0.6355	0.6460	40
21	5507	5594	5682	5772	5864	5958	6055	6153	6254	6357	6462	39
22	5508	5595	5683	5774	5866	5960	6056	6155	6255	6358	6464	38
23	5510	5596	5685	5775	5867	5961	6058	6156	6257	6360	6466	37
24	5511	5598	5686	5777	5869	5963	6059	6158	6259	6362	6467	36
25	0.5513	0.5599	0.5688	0.5778	0.5870	0.5965	0.6061	0.6160	0.6260	0.6364	0.6469	35
26	5514	5601	5689	5780	5872	5966	6063	6161	6262	6365	6471	34
27	5516	5602	5691	5781	5874	5968	6064	6163	6264	6367	6473	33
28	5517	5604	5692	5783	5875	5969	6066	6165	6265	6369	6475	32
29	5518	5605	5694	5784	5877	5971	6067	6166	6267	6371	6476	31
30	0.5520	0.5607	0.5695	0.5786	0.5878	0.5973	0.6069	0.6168	0.6269	0.6372	0.6478	30
31	5521	5608	5697	5787	5880	5974	6071	6169	6271	6374	6480	29
32	5523	5610	5698	5789	5881	5976	6072	6171	6272	6376	6482	28
33	5524	5611	5700	5790	5883	5977	6074	6173	6274	6377	6484	27
34	5526	5613	5701	5792	5884	5979	6076	6174	6276	6379	6485	26
35	0.5527	0.5614	0.5703	0.5793	0.5886	0.5981	0.6077	0.6176	0.6277	0.6381	0.6487	25
36	5528	5615	5704	5795	5888	5982	6079	6178	6279	6383	6489	24
37	5530	5617	5706	5796	5889	5984	6081	6179	6281	6384	6491	23
38	5531	5618	5707	5798	5891	5985	6082	6181	6282	6386	6492	22
39	5533	5620	5709	5800	5892	5987	6084	6183	6284	6388	6494	21
40	0.5534	0.5621	0.5710	0.5801	0.5894	0.5989	0.6085	0.6185	0.6286	0.6390	0.6496	20
41	5536	5623	5712	5803	5895	5990	6087	6186	6288	6391	6498	19
42	5537	5624	5713	5804	5897	5992	6089	6188	6289	6393	6500	18
43	5538	5626	5715	5806	5898	5993	6090	6190	6291	6395	6501	17
44	5540	5627	5716	5807	5900	5995	6092	6191	6293	6397	6503	16
45	0.5541	0.5629	0.5718	0.5809	0.5902	0.5997	0.6094	0.6193	0.6294	0.6398	0.6505	15
46	5543	5630	5719	5810	5903	5998	6095	6195	6296	6400	6507	14
47	5544	5632	5721	5812	5905	6000	6097	6196	6298	6402	6509	13
48	5546	5633	5722	5813	5906	6001	6099	6198	6300	6404	6510	12
49	5547	5635	5724	5815	5908	6003	6100	6200	6301	6406	6512	11
50	0.5549	0.5636	0.5725	0.5816	0.5909	0.6005	0.6102	0.6201	0.6303	0.6407	0.6514	10
51	5550	5637	5727	5818	5911	6006	6103	6203	6305	6409	6516	9
52	5551	5639	5728	5819	5913	6008	6105	6205	6306	6411	6518	8
53	5553	5640	5730	5821	5914	6009	6107	6206	6308	6413	6519	7
54	5554	5642	5731	5823	5916	6011	6108	6208	6310	6414	6521	6
55	0.5556	0.5643	0.5733	0.5824	0.5917	0.6013	0.6110	0.6210	0.6312	0.6416	0.6523	5
56	5557	5645	5734	5826	5919	6014	6112	6211	6313	6418	6525	4
57	5559	5646	5736	5827	5920	6016	6113	6213	6315	6420	6527	3
58	5560	5648	5737	5829	5922	6017	6115	6215	6317	6421	6529	2
59	5562	5649	5739	5830	5924	6019	6117	6216	6319	6423	6530	1
60	5563	5651	5740	5832	5925	6021	6118	6218	6320	6425	6532	0
	5° 50′	5° 49′	5° 48′	5° 47′	5° 46′	5° 45′	5° 44′	5° 43′	5° 42′	5° 41′	5° 40′	"

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	4° 20′	4° 21′	4° 22′	4° 23′	4° 24′	4° 25′	4° 26′	4° 27′	4° 28′	4° 29′	
0	0.6532	0.6642	0.6755	0.6871	0.6990	0.7112	0.7238	0.7368	0.7501	0.7639	60
1	6534	6644	6757	6873	6992	7114	7240	7370	7503	7641	59
2	6536	6646	6759	6875	6994	7116	7242	7372	7506	7644	58
3	6538	6648	6761	6877	6996	7118	7244	7374	7508	7646	57
4	6539	6650	6763	6879	6998	7120	7246	7376	7510	7648	56
5	0.6541	0.6651	0.6764	0.6881	0.7000	0.7122	0.7249	0.7379	0.7513	0.7651	55
6	6543	6653	6766	6882	7002	7124	7251	7381	7515	7653	54
7	6545	6655	6768	6884	7004	7127	7253	7383	7517	7655	53
8	6547	6657	6770	6886	7006	7129	7255	7385	7519	7658	52
9	6548	6659	6772	6888	7008	7131	7257	7387	7522	7660	51
10	0.6550	0.6661	0.6774	0.6890	0.7010	0.7133	0.7259	0.7390	0.7524	0.7663	50
11	6552	6663	6776	6892	7012	7135	7261	7392	7526	7665	49
12	6554	6664	6778	6894	7014	7137	7264	7394	7528	7667	48
13	6556	6666	6780	6896	7016	7139	7266	7396	7531	7670	47
14	6558	6668	6782	6898	7018	7141	7268	7398	7533	7672	46
15	0.6559	0.6670	0.6784	0.6900	0.7020	0.7143	0.7270	0.7401	0.7535	0.7674	45
16	6561	6672	6785	6902	7022	7145	7272	7403	7538	7677	44
17	6563	6674	6787	6904	7024	7147	7274	7405	7540	7679	43
18	6565	6676	6789	6906	7026	7149	7276	7407	7542	7681	42
19	6567	6677	6791	6908	7028	7152	7279	7409	7544	7684	41
20	0.6568	0.6679	0.6793	0.6910	0.7030	0.7154	0.7281	0.7412	0.7547	0.7686	40
21	6570	6681	6795	6912	7032	7156	7283	7414	7549	7688	39
22	6572	6683	6797	6914	7034	7158	7285	7416	7551	7691	38
23	6574	6685	6799	6916	7036	7160	7287	7418	7554	7693	37
24	6576	6687	6801	6918	7038	7162	7289	7421	7556	7696	36
25	0.6578	0.6689	0.6803	0.6920	0.7040	0.7164	0.7291	0.7423	0.7558	0.7698	35
26	6579	6691	6805	6922	7042	7166	7294	7425	7560	7700	34
27	6581	6692	6807	6924	7044	7168	7296	7427	7563	7703	33
28	6583	6694	6809	6926	7046	7170	7298	7429	7565	7705	32
29	6585	6696	6810	6928	7048	7172	7300	7432	7567	7707	31
30	0.6587	0.6698	0.6812	0.6930	0.7050	0.7175	0.7302	0.7434	0.7570	0.7710	30
31	6589	6700	6814	6932	7052	7177	7304	7436	7572	7712	29
32	6590	6702	6816	6934	7055	7179	7307	7438	7574	7714	28
33	6592	6704	6818	6936	7057	7181	7309	7441	7577	7717	27
34	6594	6706	6820	6938	7059	7183	7311	7443	7579	7719	26
35	0.6596	0.6708	0.6822	0.6940	0.7061	0.7185	0.7313	0.7445	0.7581	0.7722	25
36	6598	6709	6824	6942	7063	7187	7315	7447	7583	7724	24
37	6600	6711	6826	6944	7065	7189	7317	7450	7586	7726	23
38	6601	6713	6828	6946	7067	7191	7320	7452	7588	7729	22
39	6603	6715	6830	6948	7069	7193	7322	7454	7590	7731	21
40	0.6605	0.6717	0.6832	0.6950	0.7071	0.7196	0.7324	0.7456	0.7593	0.7734	20
41	6607	6719	6834	6952	7073	7198	7326	7458	7595	7736	19
42	6609	6721	6836	6954	7075	7200	7328	7461	7597	7738	18
43	6611	6723	6838	6956	7077	7202	7330	7463	7600	7741	17
44	6612	6725	6840	6958	7079	7204	7333	7465	7602	7743	16
45	0.6614	0.6726	0.6841	0.6960	0.7081	0.7206	0.7335	0.7467	0.7604	0.7745	15
46	6616	6728	6843	6962	7083	7208	7337	7470	7607	7748	14
47	6618	6730	6845	6964	7085	7210	7339	7472	7609	7750	13
48	6620	6732	6847	6966	7087	7212	7341	7474	7611	7753	12
49	6622	6734	6849	6968	7089	7215	7344	7476	7613	7755	11
50	0.6624	0.6736	0.6851	0.6970	0.7091	0.7217	0.7346	0.7479	0.7616	0.7757	10
51	6625	6738	6853	6972	7093	7219	7348	7481	7618	7760	9
52	6627	6740	6855	6974	7096	7221	7350	7483	7620	7762	8
53	6629	6742	6857	6976	7098	7223	7352	7485	7623	7765	7
54	6631	6743	6859	6978	7100	7225	7354	7488	7625	7767	6
55	0.6633	0.6745	0.6861	0.6980	0.7102	0.7227	0.7357	0.7490	[illegible]027	0.7769	5
56	6635	6747	6863	6982	7104	7229	7359	7492	7630	7772	4
57	6637	6749	6865	6984	7106	7232	7361	7494	7632	7774	3
58	6638	6751	6867	6986	7108	7234	7363	7497	7634	7777	2
59	6640	6753	6869	6988	7110	7236	7365	7499	7637	7779	1
60	6642	6755	6871	6990	7112	7238	7368	7501	7639	7782	0
	5° 39′	5° 38′	5° 37′	5° 36′	5° 35′	5° 34′	5° 33′	5° 32′	5° 31′	5° 30′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	4° 30′	4° 31′	4° 32′	4° 33′	4° 34′	4° 35′	4° 36′	4° 37′	4° 38′	4° 39′	
0	0.7782	0.7929	0.8081	0.8239	0.8403	0.8573	0.8751	0.8935	0.9128	0.9331	60
1	7784	7931	8084	8242	8406	8576	8754	8939	9132	9334	59
2	7786	7934	8086	8244	8409	8579	8757	8942	9135	9337	58
3	7789	7936	8089	8247	8411	8582	8760	8945	9138	9341	57
4	7791	7939	8091	8250	8414	8585	8763	8948	9142	9344	56
5	0.7794	0.7941	0.8094	0.8253	0.8417	0.8588	0.8766	0.8951	0.9145	0.9348	55
6	7796	7944	8097	8255	8420	8591	8769	8954	9148	9351	54
7	7798	7946	8099	8258	8423	8594	8772	8958	9152	9355	53
8	7801	7949	8102	8261	8425	8597	8775	8961	9155	9358	52
9	7803	7951	8104	8263	8428	8599	8778	8964	9158	9362	51
10	0.7806	0.7954	0.8107	0.8266	0.8431	0.8602	0.8781	0.8967	0.9162	0.9365	50
11	7808	7956	8110	8269	8434	8605	8784	8970	9165	9369	49
12	7811	7959	8112	8271	8437	8608	8787	8973	9168	9372	48
13	7813	7961	8115	8274	8439	8611	8790	8977	9171	9376	47
14	7815	7964	8117	8277	8442	8614	8793	8980	9175	9379	46
15	0.7818	0.7966	0.8120	0.8279	0.8445	0.8617	0.8796	0.8983	0.9178	0.9383	45
16	7820	7969	8123	8282	8448	8620	8799	8986	9181	9386	44
17	7823	7971	8125	8285	8451	8623	8802	8989	9185	9390	43
18	7825	7974	8128	8288	8453	8626	8805	8992	9188	9393	42
19	7828	7976	8131	8290	8456	8629	8808	8996	9191	9397	41
20	0.7830	0.7979	0.8133	0.8293	0.8459	0.8632	0.8811	0.8999	0.9195	0.9400	40
21	7832	7981	8136	8296	8462	8635	8814	9002	9198	9404	39
22	7835	7984	8138	8298	8465	8637	8817	9005	9201	9407	38
23	7837	7987	8141	8301	8467	8640	8821	9008	9205	9411	37
24	7840	7989	8144	8304	8470	8643	8824	9012	9208	9414	36
25	0.7842	0.7992	0.8146	0.8307	0.8473	0.8646	0.8827	0.9015	0.9212	0.9418	35
26	7845	7994	8149	8309	8476	8649	8830	9018	9215	9421	34
27	7847	7997	8152	8312	8479	8652	8833	9021	9218	9425	33
28	7850	7999	8154	8315	8482	8655	8836	9024	9222	9428	32
29	7852	8002	8157	8318	8484	8658	8839	9028	9225	9432	31
30	0.7855	0.8004	0.8159	0.8320	0.8487	0.8661	0.8842	0.9031	0.9228	0.9435	30
31	7857	8007	8162	8323	8490	8664	8845	9034	9232	9439	29
32	7859	8009	8165	8326	8493	8667	8848	9037	9235	9442	28
33	7862	8012	8167	8328	8496	8670	8851	9041	9238	9446	27
34	7864	8014	8170	8331	8499	8673	8854	9044	9242	9449	26
35	0.7867	0.8017	0.8173	0.8334	0.8502	0.8676	0.8857	0.9047	0.9245	0.9453	25
36	7869	8020	8175	8337	8504	8679	8861	9050	9249	9456	24
37	7872	8022	8178	8339	8507	8682	8864	9053	9252	9460	23
38	7874	8025	8181	8342	8510	8685	8867	9057	9255	9464	22
39	7877	8027	8183	8345	8513	8688	8870	9060	9259	9467	21
40	0.7879	0.8030	0.8186	0.8348	0.8516	0.8691	0.8873	0.9063	0.9262	0.9471	20
41	7882	8032	8188	8350	8519	8694	8876	9066	9266	9474	19
42	7884	8035	8191	8353	8522	8697	8879	9070	9269	9478	18
43	7887	8037	8194	8356	8524	8700	8882	9073	9272	9481	17
44	7889	8040	8196	8359	8527	8703	8885	9076	9276	9485	16
45	0.7891	0.8043	0.8199	0.8361	0.8530	0.8706	0.8888	0.9079	0.9279	0.9488	15
46	7894	8045	8202	8364	8533	8709	8892	9083	9283	9492	14
47	7896	8048	8204	8367	8536	8712	8895	9086	9286	9496	13
48	7899	8050	8207	8370	8539	8715	8898	9089	9289	9499	12
49	7901	8053	8210	8372	8542	8718	8901	9092	9293	9503	11
50	0.7904	0.8055	0.8212	0.8375	0.8544	0.8721	0.8904	0.9096	0.9296	0.9506	10
51	7906	8058	8215	8378	8547	8724	8907	9099	9300	9510	9
52	7909	8061	8218	8381	8550	8727	8910	9102	9303	9514	8
53	7911	8063	8220	8384	8553	8730	8913	9106	9306	9517	7
54	7914	8066	8223	8386	8556	8733	8917	9109	9310	9521	6
55	0.7916	0.8068	0.8226	0.8389	0.8559	0.8736	0.8920	0.9112	0.9313	0.9524	5
56	7919	8071	8228	8392	8562	8739	8923	9115	9317	9528	4
57	7921	8073	8231	8395	8565	8742	8926	9119	9320	9532	3
58	7924	8076	8234	8397	8568	8745	8929	9122	9324	9535	2
59	7926	8079	8236	8400	8570	8748	8932	9125	9327	9539	1
60	7929	8081	8239	8403	8573	8751	8935	9128	9331	9542	0
	5° 29′	5° 28′	5° 27′	5° 26′	5° 25′	5° 24′	5° 23′	5° 22′	5° 21′	5° 20′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

"	4° 40'	4° 41'	4° 42'	4° 43'	4° 44'	4° 45'	4° 46'	4° 47'	4° 48'	4° 49'	
0	0.9542	0.9765	1.0000	1.0248	1.0512	1.0792	1.1091	1.1413	1.1761	1.2139	60
1	9546	9769	0004	0252	0516	0797	1097	1419	1767	2145	59
2	9550	9773	0008	0257	0521	0801	1102	1424	1773	2152	58
3	9553	9777	0012	0261	0525	0806	1107	1430	1779	2159	57
4	9557	9780	0016	0265	0530	0811	1112	1436	1785	2165	56
5	0.9561	0.9784	1.0020	1.0270	1.0534	1.0816	1.1117	1.1441	1.1791	1.2172	55
6	9564	9788	0024	0274	0539	0821	1123	1447	1797	2178	54
7	9568	9792	0028	0278	0543	0826	1128	1452	1803	2185	53
8	9571	9796	0032	0282	0548	0831	1133	1458	1809	2192	52
9	9575	9800	0036	0287	0552	0835	1138	1464	1816	2198	51
10	0.9579	0.9803	1.0040	1.0291	1.0557	1.0840	1.1143	1.1469	1.1822	1.2205	50
11	9582	9807	0044	0295	0562	0845	1149	1475	1828	2212	49
12	9586	9811	0049	0300	0566	0850	1154	1481	1834	2218	48
13	9590	9815	0053	0304	0571	0855	1159	1486	1840	2225	47
14	9593	9819	0057	0308	0575	0860	1164	1492	1846	2232	46
15	0.9597	0.9823	1.0061	1.0313	1.0580	1.0865	1.1170	1.1498	1.1852	1.2239	45
16	9601	9827	0065	0317	0585	0870	1175	1503	1859	2245	44
17	9604	9830	0069	0321	0589	0875	1180	1509	1865	2252	43
18	9608	9834	0073	0326	0594	0880	1186	1515	1871	2259	42
19	9612	9838	0077	0330	0598	0884	1191	1520	1877	2266	41
20	0.9615	0.9842	1.0081	1.0334	1.0603	1.0889	1.1196	1.1526	1.1883	1.2272	40
21	9619	9846	0085	0339	0608	0894	1201	1532	1889	2279	39
22	9623	9850	0089	0343	0612	0899	1207	1538	1896	2286	38
23	9626	9854	0093	0347	0617	0904	1212	1543	1902	2293	37
24	9630	9858	0098	0352	0621	0909	1217	1549	1908	2300	36
25	0.9634	0.9861	1.0102	1.0356	1.0626	1.0914	1.1223	1.1555	1.1914	1.2307	35
26	9638	9865	0106	0360	0631	0919	1228	1561	1921	2313	34
27	9641	9869	0110	0365	0635	0924	1233	1566	1927	2320	33
28	9645	9873	0114	0369	0640	0929	1239	1572	1933	2327	32
29	9649	9877	0118	0374	0645	0934	1244	1578	1939	2334	31
30	0.9652	0.9881	1.0122	1.0378	1.0649	1.0939	1.1249	1.1584	1.1946	1.2341	30
31	9656	9885	0126	0382	0654	0944	1255	1589	1952	2348	29
32	9660	9889	0131	0387	0659	0949	1260	1595	1958	2355	28
33	9664	9893	0135	0391	0663	0954	1266	1601	1965	2362	27
34	9667	9897	0139	0395	0668	0959	1271	1607	1971	2368	26
35	0.9671	0.9901	1.0143	1.0400	1.0673	1.0964	1.1276	1.1613	1.1977	1.2375	25
36	9675	9905	0147	0404	0678	0969	1282	1619	1984	2382	24
37	9678	9908	0151	0409	0682	0974	1287	1624	1990	2389	23
38	9682	9912	0156	0413	0687	0979	1292	1630	1996	2396	22
39	9686	9916	0160	0418	0692	0984	1298	1636	2003	2403	21
40	0.9690	0.9920	1.0164	1.0422	1.0696	1.0989	1.1303	1.1642	1.2009	1.2410	20
41	9693	9924	0168	0426	0701	0994	1309	1648	2016	2417	19
42	9697	9928	0172	0431	0706	0999	1314	1654	2022	2424	18
43	9701	9932	0176	0435	0711	1004	1320	1660	2028	2431	17
44	9705	9936	0181	0440	0715	1009	1325	1665	2035	2438	16
45	0.9708	0.9940	1.0185	1.0444	1.0720	1.1015	1.1331	1.1671	1.2041	1.2445	15
46	9712	9944	0189	0449	0725	1020	1336	1677	2048	2453	14
47	9716	9948	0193	0453	0730	1025	1342	1683	2054	2460	13
48	9720	9952	0197	0458	0734	1030	1347	1689	2061	2467	12
49	9723	9956	0202	0462	0739	1035	1352	1695	2067	2474	11
50	0.9727	0.9960	1.0206	1.0467	1.0744	1.1040	1.1358	1.1701	1.2073	1.2481	10
51	9731	9964	0210	0471	0749	1045	1363	1707	2080	2488	9
52	9735	9968	0214	0475	0753	1050	1369	1713	2086	2495	8
53	9739	9972	0219	0480	0758	1055	1374	1719	2093	2502	7
54	9742	9976	0223	0484	0763	1061	1380	1725	2099	2510	6
55	0.9746	0.9980	1.0227	1.0489	1.0768	1.1066	1.1386	1.1731	1.2106	1.2517	5
56	9750	9984	0231	0493	0773	1071	1391	1737	2113	2524	4
57	9754	9988	0235	0498	0777	1076	1397	1743	2119	2531	3
58	9758	9992	0240	0502	0782	1081	1402	1749	2126	2538	2
59	9761	9996	0244	0507	0787	1086	1408	1755	2132	2545	1
60	9765	1.0000	0248	0512	0792	1091	1413	1761	2139	2553	0
	5° 19'	5° 18'	5° 17'	5° 16'	5° 15'	5° 14'	5° 13'	5° 12'	5° 11'	5° 10'	"

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVII.

The *first* correction is always to be taken at the *top*.

The *second* correction is to be taken at the *top* if the apparent distance exceed 90°.

″	4° 50′	4° 51′	4° 52′	4° 53′	4° 54′	4° 55′	4° 56′	4° 57′	4° 58′	4° 59′	
0	1.2553	1.3010	1.3522	1.4102	1.4771	1.5563	1.6532	1.7782	1.9542	2.2553	60
1	2560	3018	3531	4112	4783	5578	6550	7806	9579	2626	59
2	2567	3026	3540	4122	4795	5592	6568	7830	9615	2700	58
3	2574	3034	3549	4133	4808	5607	6587	7855	9652	2775	57
4	2582	3043	3558	4143	4820	5621	6605	7879	9690	2852	56
5	1.2589	1.3051	1.3567	1.4154	1.4832	1.5636	1.6624	1.7904	1.9727	2.2931	55
6	2596	3059	3576	4164	4844	5651	6642	7929	9765	3010	54
7	2604	3067	3586	4175	4856	5666	6661	7954	9803	3091	53
8	2611	3075	3595	4185	4869	5680	6679	7979	9842	3174	52
9	2618	3083	3604	4196	4881	5695	6698	8004	9881	3259	51
10	1.2626	1.3091	1.3613	1.4206	1.4894	1.5710	1.6717	1.8030	1.9920	2.3345	50
11	2633	3100	3623	4217	4906	5725	6736	8055	9960	3432	49
12	2640	3108	3632	4228	4918	5740	6755	8081	2.0000	3522	48
13	2648	3116	3641	4238	4931	5755	6774	8107	0040	3613	47
14	2655	3124	3650	4249	4943	5771	6793	8133	0081	3707	46
15	1.2663	1.3133	1.3660	1.4260	1.4956	1.5786	1.6812	1.8159	2.0122	2.3802	45
16	2670	3141	3669	4270	4969	5801	6832	8186	0164	3900	44
17	2678	3149	3678	4281	4981	5816	6851	8212	0206	4000	43
18	2685	3158	3688	4292	4994	5832	6871	8239	0248	4102	42
19	2692	3166	3697	4303	5007	5847	6890	8266	0291	4206	41
20	1.2700	1.3174	1.3707	1.4314	1.5019	1.5863	1.6910	1.8293	2.0334	2.4314	40
21	2707	3183	3716	4325	5032	5878	6930	8320	0378	4424	39
22	2715	3191	3726	4335	5045	5894	6950	8348	0422	4536	38
23	2722	3199	3735	4346	5058	5909	6970	8375	0467	4652	37
24	2730	3208	3745	4357	5071	5925	6990	8403	0512	4771	36
25	1.2738	1.3216	1.3754	1.4368	1.5084	1.5941	1.7010	1.8431	2.0557	2.4894	35
26	2745	3225	3764	4379	5097	5957	7030	8459	0603	5019	34
27	2753	3233	3773	4390	5110	5973	7050	8487	0649	5149	33
28	2760	3242	3783	4401	5123	5989	7071	8516	0696	5283	32
29	2768	3250	3792	4412	5136	6005	7091	8544	0744	5421	31
30	1.2775	1.3259	1.3802	1.4424	1.5149	1.6021	1.7112	1.8573	2.0792	2.5563	30
31	2783	3267	3812	4435	5162	6037	7133	8602	0840	5710	29
32	2791	3276	3821	4446	5175	6053	7154	8632	0889	5863	28
33	2798	3284	3831	4457	5189	6069	7175	8661	0939	6021	27
34	2806	3293	3841	4468	5202	6085	7196	8691	0989	6185	26
35	1.2814	1.3301	1.3851	1.4480	1.5215	1.6102	1.7217	1.8721	2.1040	2.6355	25
36	2821	3310	3860	4491	5229	6118	7238	8751	1091	6532	24
37	2829	3319	3870	4502	5242	6135	7259	8781	1143	6717	23
38	2837	3327	3880	4514	5256	6151	7281	8811	1196	6910	22
39	2845	3336	3890	4525	5269	6168	7302	8842	1249	7112	21
40	1.2852	1.3345	1.3900	1.4536	1.5283	1.6185	1.7324	1.8873	2.1303	2.7324	20
41	2860	3353	3910	4548	5296	6201	7346	8904	1358	7547	19
42	2868	3362	3919	4559	5310	6218	7368	8935	1413	7782	18
43	2876	3371	3929	4571	5324	6235	7390	8967	1469	8030	17
44	2883	3379	3939	4582	5337	6252	7412	8999	1526	8293	16
45	1.2891	1.3388	1.3949	1.4594	1.5351	1.6269	1.7434	1.9031	2.1584	2.8573	15
46	2899	3397	3959	4606	5365	6286	7456	9063	1642	8873	14
47	2907	3406	3969	4617	5379	6303	7479	9096	1701	9195	13
48	2915	3415	3979	4629	5393	6320	7501	9128	1761	9542	12
49	2923	3423	3989	4640	5407	6338	7524	9162	1822	9920	11
50	1.2931	1.3432	1.4000	1.4652	1.5421	1.6355	1.7547	1.9195	2.1883	3.0334	10
51	2939	3441	4010	4664	5435	6372	7570	9228	1946	0792	9
52	2946	3450	4020	4676	5449	6390	7593	9262	2009	1303	8
53	2954	3459	4030	4688	5463	6407	7616	9296	2073	1883	7
54	2962	3468	4040	4699	5477	6425	7639	9331	2139	2553	6
55	1.2970	1.3477	1.4050	1.4711	1.5491	1.6443	1.7663	1.9365	2.2205	3.3345	5
56	2978	3486	4061	4723	5506	6460	7686	9400	2272	4314	4
57	2986	3495	4071	4735	5520	6478	7710	9435	2341	5563	3
58	2994	3504	4081	4747	5534	6496	7734	9471	2410	7324	2
59	3002	3513	4091	4759	5549	6514	7757	9506	2481	4.0334	1
60	3010	3522	4102	4771	5563	6532	7782	9542	2553		0
	5° 9′	5° 8′	5° 7′	5° 6′	5° 5′	5° 4′	5° 3′	5° 2′	5° 1′	5° 0′	″

The *second* correction is to be taken at the *bottom* if the apparent distance be *less than* 90°.

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 20°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	6°	8°	10°	12°	16°	20°	24°	28°	32°	36°	42°	50°	58°	66°	74°	82°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ .		″	′ ″	′ ″	″	′ ″	°
6	1 38	1 46	2 7	2 34	3 43	4 51	5 59										6
7	1 46	1 40	1 53	2 12	3 1	3 57	4 50										7
8	1 55	1 36	1 44	1 56	2 35	3 17	4 0	4 42									8
9	2 8	1 40	1 39	1 45	2 12	2 47	3 23	3 58									9
10	2 23	1 46	1 36	1 39	1 56	2 24	2 53	3 23									10
11	2 38	1 54	1 38	1 37	1 46	2 8	2 32	2 56	3 16								11
12	2 53	2 3	1 41	1 35	1 41	1 56	2 16	2 35	2 52								12
13	3 9	2 13	1 46	1 37	1 37	1 48	2 4	2 19	2 32								13
14	3 25	2 23	1 52	1 39	1 34	1 42	1 54	2 5	2 16								14
15	3 41	2 34	1 58	1 42	1 33	1 38	1 45	1 54	2 3	2 13							15
16	3 58	2 45	2 4	1 46	1 32	1 34	1 38	1 46	1 53	1 59							16
17	4 15	2 56	2 10	1 50	1 33	1 32	1 34	1 39	1 44	1 48							17
18	4 32	3 7	2 17	1 54	1 34	1 30	1 31	1 34	1 37	1 40							18
19	4 49	3 18	2 24	1 58	1 35	1 29	1 29	1 32	1 33	1 34							19
20	5 5	3 28	2 31	2 2	1 37	1 28	1 28	1 30	1 30	1 29	1 26						20
21	5 21	3 39	2 38	2 6	1 39	1 29	1 27	1 27	1 27	1 25	1 21						21
22	5 36	3 49	2 46	2 11	1 40	1 29	1 25	1 25	1 24	1 22	1 18						22
23	5 51	3 59	2 53	2 16	1 42	1 29	1 25	1 24	1 22	1 20	1 15						23
24	6 5	4 9	3 0	2 22	1 43	1 30	1 24	1 23	1 21	1 18	1 12						24
25	6 19	4 18	3 7	2 26	1 45	1 30	1 24	1 21	1 19	1 16	1 9						25
26	6 32	4 27	3 14	2 31	1 47	1 31	1 25	1 21	1 17	1 14	1 7						26
27	6 45	4 35	3 20	2 35	1 49	1 32	1 25	1 21	1 17	1 13	1 6						27
28		4 42	3 26	2 38	1 50	1 33	1 25	1 21	1 17	1 13	1 4	50					28
29		4 49	3 32	2 41	1 52	1 33	1 25	1 21	1 17	1 14	1 5	50					29
30			3 37	2 45	1 54	1 34	1 25	1 21	1 18	1 15	1 7	50					30
31			3 42	2 49	1 56	1 34	1 25	1 20	1 17	1 15	1 7	51					31
32				2 52	1 58	1 34	1 24	1 19	1 17	1 14	1 7	51					32
33				2 55	1 59	1 33	1 24	1 19	1 16	1 13	1 8	52					33
34					1 59	1 33	1 23	1 18	1 15	1 13	1 8	53					34
35					1 59	1 32	1 22	1 17	1 14	1 12	1 8	53					35
36					1 59	1 31	1 20	1 15	1 13	1 11	1 7	54	36				36
37					1 59	1 30	1 19	1 14	1 12	1 10	1 6	54	37				37
38						1 29	1 18	1 13	1 11	1 9	1 6	55	38				38
39						1 28	1 17	1 11	1 10	1 9	1 5	55	39				39
40						1 27	1 15	1 10	1 9	1 8	1 4	55	39				40
41						1 26	1 13	1 9	1 8	1 7	1 3	55	39				41
42							1 11	1 7	1 7	1 6	1 2	55	40				42
43							1 10	1 5	1 5	1 5	1 2	55	40				43
44							1 9	1 3	1 4	1 4	1 1	55	40	29			44
46							1 7	1 0	1 1	1 2	1 0	54	41	30			46
48								56	56	59	58	53	43	31			48
50								52	52	55	55	51	43	33			50
52									48	50	51	49	43	35	24		52
54									44	45	47	47	43	36	25		54
56										40	44	45	42	35	27		56
58										35	40	43	40	34	27		58
60											36	41	39	33	26	21	60
62											33	38	38	32	26	22	62
64											30	35	37	32	27	22	64
66												32	36	31	27	23	66
68												29	34	30	26	23	68
70												27	32	29	26	22	70
72												25	29	28	25	21	72
74													27	27	24	21	74
76													25	26	24	20	76
78													23	25	23	20	78
80													21	24	22	20	80
82														23	21		82
84														22	21		84
86														21	20		86
	6°	8°	10°	12°	16°	20°	24°	28°	32°	36°	42°	50°	58°	66°	74°	82°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 24°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 28	1 31	1 35	1 42	1 52	2 3	2 16	2 46	3 16	3 47	4 19	4 50	5 20	5 50	6 20	6 50	6
7	1 35	1 27	1 30	1 34	1 39	1 46	1 54	2 15	2 38	3 3	3 29	3 55	4 20	4 46	5 10	5 34	7
8	1 45	1 32	1 26	1 28	1 30	1 35	1 41	1 58	2 17	2 37	2 58	3 18	3 39	4 1	4 20	4 39	8
9	1 56	1 39	1 30	1 25	1 26	1 29	1 34	1 44	1 59	2 15	2 31	2 48	3 6	3 24	3 40	3 56	9
10	2 8	1 48	1 36	1 29	1 25	1 26	1 28	1 35	1 45	1 57	2 13	2 27	2 43	2 58	3 12	3 26	10
11	2 21	1 58	1 43	1 34	1 28	1 24	1 26	1 30	1 36	1 46	1 58	2 11	2 24	2 37	2 49	3 0	11
12	2 36	2 9	1 52	1 41	1 33	1 27	1 24	1 26	1 30	1 37	1 47	1 58	2 9	2 20	2 29	2 38	12
13	2 51	2 20	2 1	1 48	1 38	1 31	1 27	1 24	1 27	1 32	1 40	1 4[illegible]	1 57	2 6	2 14	2 22	13
14	3 6	2 31	2 10	1 55	1 43	1 35	1 30	1 23	1 25	1 28	1 33	1 40	1 48	1 55	2 2	2 10	14
15	3 21	2 42	2 20	2 2	1 50	1 39	1 33	1 24	1 23	1 25	1 24	1 34	1 40	1 46	1 52	1 59	15
16	3 36	2 54	2 30	2 9	1 56	1 44	1 36	1 26	1 22	1 23	1 25	1 29	1 33	1 38	1 44	1 50	16
17	3 51	3 6	2 40	2 17	2 2	1 49	1 39	1 28	1 23	1 21	1 23	1 26	1 29	1 34	1 39	1 43	17
18	4 6	3 18	2 49	2 25	2 8	1 54	1 43	1 31	1 24	1 20	1 21	1 23	1 26	1 30	1 34	1 37	18
19	4 21	3 30	2 59	2 33	2 14	1 59	1 47	1 33	1 25	1 21	1 20	1 22	1 24	1 27	1 30	1 32	19
20	4 35	3 42	3 9	2 41	2 21	2 5	1 52	1 36	1 2[illegible]	[illegible]	1 19	1 20	1 22	1 24	1 26	1 28	20
21	4 50	3 54	3 19	2 50	2 28	2 11	1 56	1 39	1 [illegible]9	1 23	1 20	1 19	1 20	1 21	1 23	1 25	21
22	5 4	4 6	3 28	2 58	2 35	2 17	2 1	1 42	1 31	1 24	1 20	1 18	1 19	1 19	1 20	1 22	22
23	5 19	4 18	3 38	3 6	2 43	2 23	2 6	1 46	1 33	1 25	1 21	1 18	1 18	1 18	1 18	1 19	23
24	5 33	4 29	3 48	3 14	2 51	2 29	2 12	1 50	1 36	1 27	1 22	1 19	1 17	1 17	1 17	1 17	24
25	5 47	4 41	3 57	3 22	2 58	2 35	2 17	1 53	1 38	1 28	1 23	1 20	1 18	1 16	1 16	1 16	25
26	6 1	4 52	4 6	3 30	3 [illegible]	[illegible] 41	2 22	1 57	1 41	1 30	1 24	1 20	1 18	1 16	1 15	1 15	26
27	6 14	5 4	4 15	3 38	3 10	2 47	2 27	2 0	1 43	1 32	1 25	1 21	1 18	1 15	1 14	1 13	27
28	6 27	5 15	4 23	3 45	3 16	2 53	2 32	2 4	1 46	1 34	1 27	1 21	1 18	1 15	1 13	1 12	28
29	6 38	5 26	4 32	3 53	3 22	2 58	2 38	2 8	1 49	1 36	1 28	1 22	1 18	1 15	1 13	1 11	29
30	6 50	5 36	4 41	4 0	3 28	3 3	2 44	2 12	1 52	1 38	1 29	1 23	1 19	1 15	1 13	1 11	30
31	7 0	5 45	4 50	4 7	3 34	3 8	2 49	2 16	1 55	1 40	1 30	1 24	1 19	1 15	1 13	1 11	31
32		5 53	4 58	4 14	3 40	3 13	2 54	2 19	1 57	1 41	1 31	1 24	1 19	1 15	1 13	1 11	32
33			5 5	4 20	3 46	3 18	2 58	2 22	1 59	1 42	1 31	1 24	1 19	1 15	1 13	1 11	33
34				4 25	3 51	3 22	3 1	2 24	2 1	1 43	1 32	1 25	1 20	1 15	1 13	1 11	34
35					3 56	3 26	3 3	2 26	2 2	1 45	1 33	1 25	1 20	1 15	1 13	1 11	35
36						3 30	3 5	2 28	2 4	1 46	1 34	1 25	1 20	1 15	1 12	1 10	36
37							3 7	2 30	2 6	1 47	1 35	1 25	1 20	1 15	1 12	1 10	37
38								2 32	2 7	1 48	1 35	1 25	1 20	1 15	1 12	1 10	38
39								2 34	2 8	1 49	1 35	1 25	1 19	1 15	1 12	1 10	39
40									2 9	1 50	1 35	1 25	1 19	1 15	1 11	1 9	40
41									2 10	1 50	1 35	1 25	1 19	1 15	1 11	1 8	41
42										1 51	1 36	1 25	1 19	1 14	1 10	1 7	42
43										1 52	1 36	1 25	1 18	1 13	1 9	1 6	43
44											1 36	1 25	1 18	1 13	1 8	1 5	44
46											1 36	1 25	1 17	1 12	1 7	1 3	46
48												1 25	1 17	1 10	1 5	1 1	48
50													1 17	1 8	1 4	59	50
52														1 7	1 3	58	52
54															1 2	57	54
56																56	56
58																	58
60																	60
62																	62
64																	64
66																	66
68																	68
70																	70
72																	72
74																	74
76																	76
78																	78
80																	80
82																	82
84																	84
86																	86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 24°.

☽'s App. Alt.	*Apparent Altitude of the Sun, Star or Planet.*																☽'s App. Alt.
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	
°		′ ″				′				′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ′	°
6																	6
7																	7
8	4 58																8
9	4 12																9
10	3 39	3 51															10
11	3 11	3 21	3 30														11
12	2 48	2 56	3 5	3 12													12
13	2 30	2 37	2 44	2 49													13
14	2 16	2 22	2 27	2 32													14
15	2 4	2 9	2 14	2 18													15
16	1 54	1 59	2 3	2 6	2 11												16
17	1 46	1 50	1 53	1 56	2 0												17
18	1 40	1 43	1 45	1 47	1 51												18
19	1 35	1 37	1 39	1 41	1 43												19
20	1 30	1 32	1 33	1 34	1 36	1 38											20
21	1 26	1 27	1 28	1 29	1 30	1 31											21
22	1 22	1 23	1 24	1 24	1 25	1 25											22
23	1 20	1 20	1 21	1 21	1 21	1 21											23
24	1 18	1 18	1 19	1 19	1 18	1 17	1 15										24
25	1 16	1 16	1 17	1 17	1 16	1 14	1 11										25
26	1 14	1 14	1 14	1 14	1 13	1 11	1 8										26
27	1 13	1 13	1 12	1 12	1 11	1 9	1 6										27
28	1 12	1 12	1 11	1 10	1 9	1 7	1 4	1 1									28
29	1 11	1 11	1 10	1 9	1 8	1 5	1 2	59									29
30	1 11	1 10	1 9	1 8	1 7	1 4	1 0	57									30
31	1 10	1 9	1 8	1 8	1 6	1 2	58	55									31
32	1 9	1 9	1 8	1 7	1 5	1 1	57	54	51								32
33	1 9	1 8	1 7	1 6	1 4	1 1	57	53	50								33
34	1 9	1 7	1 6	1 5	1 3	1 0	57	53	49								34
35	1 9	1 7	1 6	1 5	1 2	1 0	56	52	48								35
36	1 8	1 7	1 6	1 4	1 2	1 0	56	51	47	44							36
37	1 8	1 6	1 5	1 3	1 1	58	55	51	46	43							37
38	1 8	1 6	1 5	1 3	1 0	57	54	50	46	43							38
39	1 8	1 6	1 4	1 2	59	56	52	48	45	42							39
40	1 7	1 5	1 4	1 2	59	55	51	47	44	41	39						40
41	1 6	1 4	1 3	1 1	58	54	50	47	44	41	38						41
42	1 5	1 4	1 3	1 1	57	54	50	47	44	41	38						42
43	1 4	1 3	1 2	1 0	56	53	50	47	43	40	37	34					43
44	1 3	1 2	1 1	59	56	53	50	47	43	40	37	34					44
46	1 1	1 0	59	58	55	52	49	46	43	40	37	34	32				46
48	59	59	58	57	54	51	49	46	43	40	37	34	32				48
50	57	57	56	55	53	50	48	45	43	40	37	34	32	30			50
52	55	54	53	52	51	49	47	45	43	40	37	34	32	30			52
54	54	52	51	50	49	47	46	44	42	39	37	34	32	29	27		54
56	53	51	49	48	47	45	44	43	41	38	36	34	31	29	27		56
58	52	49	47	46	45	44	43	42	40	37	35	33	31	29	27	26	58
60		47	45	44	43	42	41	40	38	36	34	32	30	28	27	26	60
62			43	43	41	40	39	38	37	35	33	31	29	28	27	26	62
64				42	39	38	38	37	36	34	32	30	29	28	27	26	64
66					38	37	37	36	35	33	31	29	28	27	26	25	66
68					37	35	35	34	34	33	31	29	28	27	26	25	68
70						34	34	33	33	32	30	28	27	26	25	25	70
72						33	33	32	32	31	29	28	26	25	24	25	72
74							32	31	31	30	29	28	26	25	24		74
76							31	30	30	29	28	27	25	24	24		76
78								29	29	29	28	27	25	24			78
80								28	28	28	27	26	25	24			80
82									27	27	26	25	24				82
84									26	26	25	25	24				84
86										26	25	25					86
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 28°.

D's App. Alt.	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	D's App. Alt.
	Apparent Altitude of the Sun, Star or Planet.																
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ′	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 20	1 23	1 27	1 33	1 40	1 49	2 00	2 28	2 56	3 24	3 53	4 21	4 48	5 15	5 42	6 9	6
7	1 25	1 20	1 23	1 27	1 32	1 38	1 45	2 5	2 26	2 49	3 13	3 36	3 58	4 20	4 43	5 6	7
8	1 32	1 24	1 20	1 22	1 25	1 29	1 35	1 50	2 7	2 26	2 46	3 4	3 23	3 42	4 1	4 20	8
9	1 41	1 29	1 23	1 20	1 22	1 24	1 28	1 39	1 52	2 7	2 22	2 37	2 53	3 9	3 25	3 41	9
10	1 53	1 37	1 28	1 23	1 20	1 21	1 23	1 30	1 39	1 52	2 5	2 18	2 31	2 44	2 58	3 11	10
11	2 6	1 46	1 34	1 27	1 23	1 20	1 21	1 24	1 31	1 41	1 52	2 4	2 15	2 26	2 37	2 48	11
12	2 19	1 56	1 41	1 32	1 26	1 22	1 19	1 21	1 26	1 33	1 42	1 52	2 1	2 10	2 20	2 30	12
13	2 32	2 6	1 49	1 38	1 30	1 25	1 21	1 20	1 23	1 28	1 34	1 42	1 49	1 57	2 6	2 15	13
14	2 46	2 17	1 58	1 44	1 34	1 28	1 23	1 19	1 21	1 24	1 28	1 34	1 40	1 47	1 55	2 3	14
15	3 00	2 28	2 7	1 51	1 39	1 32	1 25	1 20	1 19	1 21	1 24	1 28	1 33	1 39	1 45	1 52	15
16	3 14	2 39	2 16	1 58	1 45	1 36	1 28	1 21	1 18	1 19	1 21	1 24	1 28	1 33	1 38	1 44	16
17	3 28	2 51	2 25	2 5	1 51	1 41	1 32	1 23	1 19	1 18	1 19	1 21	1 24	1 28	1 33	1 38	17
18	3 41	3 2	2 35	2 13	1 58	1 46	1 36	1 25	1 20	1 17	1 18	1 19	1 21	1 24	1 28	1 33	18
19	3 55	3 13	2 45	2 21	2 5	1 52	1 41	1 27	1 21	1 18	1 16	1 17	1 18	1 21	1 24	1 28	19
20	4 9	3 24	2 55	2 29	2 11	1 57	1 46	1 30	1 23	1 18	1 16	1 15	1 16	1 18	1 21	1 24	20
21	4 23	3 35	3 4	2 37	2 17	2 3	1 51	1 33	1 25	1 19	1 16	1 14	1 15	1 16	1 18	1 20	21
22	4 36	3 46	3 13	2 45	2 24	2 9	1 56	1 36	1 27	1 20	1 16	1 13	1 14	1 15	1 16	1 17	22
23	4 49	3 57	3 22	2 53	2 31	2 14	2 1	1 40	1 29	1 22	1 17	1 13	1 13	1 13	1 14	1 15	23
24	5 2	4 8	3 31	3 0	2 37	2 20	2 6	1 43	1 31	1 24	1 18	1 14	1 12	1 12	1 12	1 13	24
25	5 16	4 19	3 40	3 8	2 43	2 26	2 11	1 47	1 34	1 26	1 19	1 15	1 13	1 11	1 11	1 12	25
26	5 29	4 30	3 49	3 15	2 50	2 32	2 16	1 51	1 36	1 28	1 20	1 15	1 13	1 11	1 11	1 11	26
27	5 42	4 41	3 58	3 23	2 57	2 38	2 21	1 55	1 39	1 30	1 21	1 16	1 13	1 11	1 10	1 10	27
28	5 55	4 52	4 7	3 30	3 4	2 44	2 26	1 59	1 42	1 32	1 22	1 17	1 14	1 11	1 10	1 10	28
29	6 7	5 3	4 16	3 38	3 11	2 50	2 31	2 3	1 45	1 34	1 24	1 18	1 14	1 12	1 10	1 10	29
30	6 19	5 13	4 25	3 45	3 18	2 55	2 36	2 7	1 47	1 36	1 26	1 19	1 15	1 12	1 10	1 9	30
31	6 31	5 23	4 34	3 52	3 25	3 1	2 41	2 10	1 50	1 38	1 27	1 20	1 15	1 12	1 10	1 9	31
32	6 42	5 32	4 43	3 59	3 31	3 7	2 46	2 13	1 53	1 40	1 29	1 21	1 16	1 12	1 10	1 9	32
33	6 53	5 41	4 51	4 6	3 37	3 12	2 51	2 17	1 56	1 42	1 31	1 22	1 16	1 12	1 10	1 9	33
34	7 4	5 50	4 58	4 13	3 43	3 17	2 55	2 20	1 58	1 44	1 32	1 23	1 17	1 12	1 10	1 9	34
35	7 15	5 59	5 5	4 20	3 48	3 21	2 59	2 23	2 00	1 46	1 33	1 23	1 17	1 13	1 10	1 8	35
36		6 8	5 11	4 26	3 53	3 25	3 3	2 26	2 3	1 47	1 34	1 24	1 18	1 13	1 10	1 8	36
37			5 17	4 32	3 58	3 29	3 7	2 29	2 5	1 49	1 35	1 25	1 18	1 13	1 10	1 8	37
38				4 38	4 2	3 33	3 10	2 32	2 7	1 51	1 36	1 26	1 19	1 14	1 10	1 8	38
39					4 6	3 37	3 12	2 34	2 9	1 52	1 37	1 27	1 19	1 14	1 11	1 8	39
40						3 41	3 15	2 37	2 11	1 53	1 38	1 27	1 20	1 15	1 11	1 8	40
41							3 17	2 40	2 13	1 54	1 39	1 28	1 20	1 15	1 11	1 8	41
42								2 42	2 15	1 55	1 40	1 29	1 21	1 15	1 10	1 7	42
43								2 44	2 17	1 56	1 40	1 29	1 21	1 15	1 10	1 7	43
44									2 18	1 57	1 41	1 30	1 21	1 15	1 10	1 7	44
46									2 19	1 59	1 42	1 30	1 22	1 15	1 10	1 7	46
48										2 0	1 43	1 31	1 22	1 15	1 10	1 6	48
50											1 44	1 32	1 23	1 15	1 10	1 6	50
52												1 33	1 24	1 15	1 9	1 5	52
54													1 25	1 15	1 9	1 5	54
56														1 15	1 9	1 4	56
58															1 9	1 3	58
60																1 3	60
62																	62
64																	64
66																	66
68																	68
70																	70
72																	72
74																	74
76																	76
78																	78
80																	80
82																	82
84																	84
86																	86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 28°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	′ ″	′	′		′	′	°
6	6 37	7 4															6
7	5 28	5 49	6 8														7
8	4 40	4 57	5 11														8
9	3 58	4 13	4 26	4 38													9
10	3 25	3 38	3 50	4 2													10
11	3 0	3 12	3 23	3 33													11
12	2 40	2 50	2 59	3 7	3 22												12
13	2 24	2 33	2 41	2 48	3 0												13
14	2 11	2 18	2 25	2 31	2 42												14
15	1 59	2 6	2 12	2 17	2 27												15
16	1 50	1 56	2 1	2 6	2 14	2 21											16
17	1 43	1 48	1 52	1 56	2 3	2 9											17
18	1 37	1 41	1 45	1 48	1 54	1 59											18
19	1 31	1 35	1 38	1 41	1 46	1 50											19
20	1 26	1 29	1 32	1 34	1 38	1 42	1 45										20
21	1 22	1 25	1 27	1 29	1 32	1 36	1 38										21
22	1 19	1 21	1 23	1 25	1 28	1 30	1 32										22
23	1 17	1 18	1 20	1 22	1 24	1 26	1 27										23
24	1 15	1 16	1 17	1 18	1 20	1 22	1 23	1 24									24
25	1 13	1 14	1 14	1 15	1 16	1 18	1 19	1 19									25
26	1 11	1 12	1 12	1 13	1 13	1 14	1 15	1 15									26
27	1 10	1 11	1 11	1 11	1 11	1 11	1 12	1 12									27
28	1 10	1 10	1 10	1 10	1 10	1 9	1 9	1 9	1 9								28
29	1 10	1 10	1 10	1 9	1 9	1 8	1 7	1 6	1 6								29
30	1 9	1 9	1 9	1 8	1 8	1 7	1 6	1 4	1 3								30
31	1 8	1 8	1 7	1 7	1 6	1 5	1 4	1 2	1 1								31
32	1 8	1 7	1 6	1 6	1 5	1 4	1 3	1 1	1 0	59							32
33	1 7	1 6	1 5	1 5	1 4	1 3	1 2	1 0	58	56							33
34	1 7	1 5	1 4	1 4	1 3	1 2	1 1	59	57	54							34
35	1 7	1 5	1 4	1 3	1 2	1 1	1 0	58	55	53							35
36	1 6	1 5	1 4	1 3	1 1	1 0	58	56	54	52	51						36
37	1 6	1 4	1 3	1 2	1 0	59	57	55	53	51	50						37
38	1 6	1 4	1 3	1 1	59	58	56	54	52	50	49						38
39	1 6	1 4	1 2	1 0	59	57	55	53	51	49	47						39
40	1 6	1 4	1 2	1 0	58	57	55	52	50	48	46	44					40
41	1 6	1 4	1 2	1 0	58	56	54	51	49	47	45	43					41
42	1 5	1 4	1 2	59	57	55	53	50	48	46	44	42					42
43	1 5	1 3	1 1	59	57	55	53	50	48	46	44	42	41				43
44	1 5	1 3	1 1	59	56	54	52	50	47	45	43	41	40				44
46	1 4	1 2	1 0	58	55	53	51	49	47	44	42	40	39				46
48	1 3	1 1	59	57	54	52	50	48	46	43	41	39	38	37			48
50	1 3	1 1	58	56	53	51	49	47	45	42	40	38	37	36			50
52	1 2	1 0	57	55	52	50	48	46	44	42	40	38	36	35	34		52
54	1 2	59	56	54	51	49	47	45	43	41	39	37	35	34	33		54
56	1 1	58	55	53	50	48	46	44	42	40	38	36	35	34	33	32	56
58	1 0	57	54	52	49	47	45	43	41	39	37	36	35	34	32	31	58
60	58	55	53	51	48	46	44	42	40	38	37	36	35	34	32	31	60
62	56	54	52	50	47	45	43	41	39	38	37	36	35	34	32	31	62
64		52	50	49	46	44	42	40	38	37	36	35	34	33	32	30	64
66			48	48	45	43	41	39	38	37	36	35	34	33	31	29	66
68				46	43	41	40	38	37	36	35	34	33	32	30	28	68
70					42	40	39	38	37	36	35	34	33	31	29		70
72					41	39	38	37	36	35	34	33	32	30	28		72
74						39	37	36	35	34	33	32	30	28			74
76						38	36	35	34	34	33	31	29	27			76
78							36	34	34	33	32	30	28				78
80							35	34	33	32	31	30	28				80
82								33	32	31	30	29					82
84								32	32	31	30	29					84
86									31	30	29						86
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 28°.

☽'s App. Alt.	*Apparent Altitude of the Sun, Star or Planet.*																		☽'s App. Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°		
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ′	′ ″	′ ″	′ ″	′ ″	′ ″		°
6	1 20	1 23	1 27	1 33	1 40	1 49	2 00	2 28	2 56	3 24	3 53	4 21	4 48	5 15	5 42	6 9		6
7	1 25	1 20	1 23	1 27	1 32	1 38	1 45	2 5	2 26	2 49	3 13	3 36	3 58	4 20	4 43	5 6		7
8	1 32	1 24	1 20	1 22	1 25	1 29	1 35	1 50	2 7	2 26	2 46	3 4	3 23	3 42	4 1	4 20		8
9	1 41	1 29	1 23	1 20	1 22	1 24	1 28	1 39	1 52	2 7	2 22	2 37	2 53	3 9	3 25	3 41		9
10	1 53	1 37	1 28	1 23	1 20	1 21	1 23	1 30	1 39	1 52	2 5	2 18	2 31	2 44	2 58	3 11		10
11	2 6	1 46	1 34	1 27	1 23	1 20	1 21	1 24	1 31	1 41	1 52	2 4	2 15	2 26	2 37	2 48		11
12	2 19	1 56	1 41	1 32	1 26	1 22	1 19	1 21	1 26	1 33	1 42	1 52	2 1	2 10	2 20	2 30		12
13	2 32	2 6	1 49	1 38	1 30	1 25	1 21	1 20	1 23	1 28	1 34	1 42	1 49	1 57	2 6	2 15		13
14	2 46	2 17	1 58	1 44	1 34	1 28	1 23	1 19	1 21	1 24	1 28	1 34	1 40	1 47	1 55	2 3		14
15	3 00	2 28	2 7	1 51	1 39	1 32	1 25	1 20	1 19	1 21	1 24	1 28	1 33	1 39	1 45	1 52		15
16	3 14	2 39	2 16	1 58	1 45	1 36	1 28	1 21	1 18	1 19	1 21	1 24	1 28	1 33	1 38	1 44		16
17	3 28	2 51	2 25	2 5	1 51	1 41	1 32	1 23	1 19	1 18	1 19	1 21	1 24	1 28	1 33	1 38		17
18	3 41	3 2	2 35	2 13	1 58	1 46	1 36	1 25	1 2[illegible]	1 17	1 18	1 19	1 21	1 24	1 28	1 33		18
19	3 55	3 13	2 45	2 21	2 5	1 52	1 41	1 27	1 21	1 18	1 16	1 17	1 18	1 21	1 24	1 28		19
20	4 9	3 24	2 55	2 29	2 11	1 57	1 46	1 30	1 23	1 18	1 16	1 15	1 16	1 18	1 21	1 24		20
21	4 23	3 35	3 4	2 37	2 17	2 3	1 51	1 33	1 25	1 19	1 16	1 14	1 15	1 16	1 18	1 20		21
22	4 36	3 46	3 13	2 45	2 24	2 9	1 56	1 36	1 27	1 20	1 16	1 13	1 14	1 15	1 16	1 17		22
23	4 49	3 57	3 22	2 53	2 31	2 14	2 1	1 40	1 29	1 22	1 17	1 13	1 13	1 13	1 14	1 15		23
24	5 2	4 8	3 31	3 0	2 37	2 20	2 6	1 43	1 31	1 24	1 18	1 14	1 12	1 12	1 12	1 13		24
25	5 16	4 19	3 40	3 8	2 43	2 26	2 11	1 47	1 34	1 26	1 19	1 15	1 13	1 11	1 11	1 12		25
26	5 29	4 30	3 49	3 15	2 50	2 32	2 16	1 51	1 36	1 28	1 20	1 15	1 13	1 11	1 11	1 11		26
27	5 42	4 41	3 58	3 23	2 57	2 38	2 21	1 55	1 39	1 30	1 21	1 16	1 13	1 11	1 10	1 10		27
28	5 55	4 52	4 7	3 30	3 4	2 44	2 26	1 59	1 42	1 32	1 22	1 17	1 14	1 11	1 10	1 10		28
29	6 7	5 3	4 16	3 38	3 11	2 50	2 31	2 3	1 45	1 34	1 24	1 18	1 14	1 12	1 10	1 10		29
30	6 19	5 13	4 25	3 45	3 18	2 55	2 36	2 7	1 47	1 36	1 26	1 19	1 15	1 12	1 10	1 9		30
31	6 31	5 23	4 34	3 52	3 25	3 1	2 41	2 10	1 50	1 38	1 27	1 20	1 15	1 12	1 10	1 9		31
32	6 42	5 32	4 43	3 59	3 31	3 7	2 46	2 13	1 53	1 40	1 29	1 21	1 16	1 12	1 10	1 9		32
33	6 53	5 41	4 51	4 6	3 37	3 12	2 51	2 17	1 56	1 42	1 31	1 22	1 16	1 12	1 10	1 9		33
34	7 4	5 50	4 58	4 13	3 43	3 17	2 55	2 20	1 58	1 44	1 32	1 23	1 17	1 12	1 10	1 9		34
35	7 15	5 59	5 5	4 20	3 48	3 21	2 59	2 23	2 00	1 46	1 33	1 23	1 17	1 13	1 10	1 8		35
36		6 8	5 11	4 26	3 53	3 25	3 3	2 26	2 3	1 47	1 34	1 24	1 18	1 13	1 10	1 8		36
37			5 17	4 32	3 58	3 29	3 7	2 29	2 5	1 49	1 35	1 25	1 18	1 13	1 10	1 8		37
38				4 38	4 2	3 33	3 10	2 32	2 7	1 51	1 36	1 26	1 19	1 14	1 10	1 8		38
39					4 6	3 37	3 12	2 34	2 9	1 52	1 37	1 27	1 19	1 14	1 11	1 8		39
40						3 41	3 15	2 37	2 11	1 53	1 38	1 27	1 20	1 15	1 11	1 8		40
41							3 17	2 40	2 13	1 54	1 39	1 28	1 20	1 15	1 11	1 8		41
42								2 42	2 15	1 55	1 40	1 29	1 21	1 15	1 10	1 7		42
43								2 44	2 17	1 56	1 40	1 29	1 21	1 15	1 10	1 7		43
44									2 18	1 57	1 41	1 30	1 21	1 15	1 10	1 7		44
46									2 19	1 59	1 42	1 30	1 22	1 15	1 10	1 7		46
48										2 0	1 43	1 31	1 22	1 15	1 10	1 6		48
50											1 44	1 32	1 23	1 15	1 10	1 6		50
52												1 33	1 24	1 15	1 9	1 5		52
54													1 25	1 15	1 9	1 5		54
56														1 15	1 9	1 4		56
58															1 9	1 3		58
60																1 3		60
62																		62
64																		64
66																		66
68																		68
70																		70
72																		72
74																		74
76																		76
78																		78
80																		80
82																		82
84																		84
86																		86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°		

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 28°.

☽'s App. Alt.	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	☽'s App. Alt.
	Apparent Altitude of the Sun, Star or Planet.																
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	′ ″	′	′		′	′	°
6	6 37	7 4															6
7	5 28	5 49	6 8														7
8	4 40	4 57	5 11														8
9	3 58	4 13	4 26	4 38													9
10	3 25	3 38	3 50	4 2													10
11	3 0	3 12	3 23	3 33													11
12	2 40	2 50	2 59	3 7	3 22												12
13	2 24	2 33	2 41	2 48	3 0												13
14	2 11	2 18	2 25	2 31	2 42												14
15	1 59	2 6	2 12	2 17	2 27												15
16	1 50	1 56	2 1	2 6	2 14	2 21											16
17	1 43	1 48	1 52	1 56	2 3	2 9											17
18	1 37	1 41	1 45	1 48	1 54	1 59											18
19	1 31	1 35	1 38	1 41	1 46	1 50											19
20	1 26	1 29	1 32	1 34	1 38	1 42	1 45										20
21	1 22	1 25	1 27	1 29	1 32	1 36	1 38										21
22	1 19	1 21	1 23	1 25	1 28	1 30	1 32										22
23	1 17	1 18	1 20	1 22	1 24	1 26	1 27										23
24	1 15	1 16	1 17	1 18	1 20	1 22	1 23	1 24									24
25	1 13	1 14	1 14	1 15	1 16	1 18	1 19	1 19									25
26	1 11	1 12	1 12	1 13	1 13	1 14	1 15	1 15									26
27	1 10	1 11	1 11	1 11	1 11	1 11	1 12	1 12									27
28	1 10	1 10	1 10	1 10	1 10	1 9	1 9	1 9	1 9								28
29	1 10	1 10	1 10	1 9	1 9	1 8	1 7	1 6	1 6								29
30	1 9	1 9	1 9	1 8	1 8	1 7	1 6	1 4	1 3								30
31	1 8	1 8	1 7	1 7	1 6	1 5	1 4	1 2	1 1								31
32	1 8	1 7	1 6	1 6	1 5	1 4	1 3	1 1	1 0	59							32
33	1 7	1 6	1 5	1 5	1 4	1 3	1 2	1 0	58	56							33
34	1 7	1 5	1 4	1 4	1 3	1 2	1 1	59	57	54							34
35	1 7	1 5	1 4	1 3	1 2	1 1	1 0	58	55	53							35
36	1 6	1 5	1 4	1 3	1 1	1 0	58	56	54	52	51						36
37	1 6	1 4	1 3	1 2	1 0	59	57	55	53	51	50						37
38	1 6	1 4	1 3	1 1	59	58	56	54	52	50	49						38
39	1 6	1 4	1 2	1 0	59	57	55	53	51	49	47						39
40	1 6	1 4	1 2	1 0	58	57	55	52	50	48	46	44					40
41	1 6	1 4	1 2	1 0	58	56	54	51	49	47	45	43					41
42	1 5	1 4	1 2	59	57	55	53	50	48	46	44	42					42
43	1 5	1 3	1 1	59	57	55	53	50	48	46	44	42	41				43
44	1 5	1 3	1 1	59	56	54	52	50	47	45	43	41	40				44
46	1 4	1 2	1 0	58	55	53	51	49	47	44	42	40	39				46
48	1 3	1 1	59	57	54	52	50	48	46	43	41	39	38	37			48
50	1 3	1 1	58	56	53	51	49	47	45	42	40	38	37	36			50
52	1 2	1 0	57	55	52	50	48	46	44	42	40	38	36	35	34		52
54	1 2	59	56	54	51	49	47	45	43	41	39	37	35	34	33		54
56	1 1	58	55	53	50	48	46	44	42	40	38	36	35	34	33	32	56
58	1 0	57	54	52	49	47	45	43	41	39	37	36	35	34	32	31	58
60	58	55	53	51	48	46	44	42	40	38	37	36	35	34	32	31	60
62	56	54	52	50	47	45	43	41	39	38	37	36	35	34	32	31	62
64		52	50	49	46	44	42	40	38	37	36	35	34	33	32	30	64
66			48	48	45	43	41	39	38	37	36	35	34	33	31	29	66
68				46	43	41	40	38	37	36	35	34	33	32	30	28	68
70					42	40	39	38	37	36	35	34	33	31	29		70
72					41	39	38	37	36	35	34	33	32	30	28		72
74						39	37	36	35	34	33	32	30	28			74
76						38	36	35	34	34	33	31	29	27			76
78							36	34	34	33	32	30	28				78
80							35	34	33	32	31	30	28				80
82								33	32	31	30	29					82
84								32	32	31	30	29					84
86									31	30	29						86
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 32°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 18	1 21	1 25	1 30	1 37	1 47	1 59	2 23	2 48	3 13	3 39	4 5	4 30	4 55	5 20	5 45	6
7	1 23	1 18	1 21	1 24	1 28	1 33	1 42	2 0	2 18	2 37	2 58	3 20	3 42	4 4	4 25	4 46	7
8	1 30	1 22	1 18	1 20	1 22	1 25	1 29	1 42	1 57	2 14	2 32	2 50	3 8	3 26	3 44	4 2	8
9	1 38	1 27	1 20	1 18	1 19	1 21	1 23	1 31	1 44	1 58	2 12	2 26	2 41	2 56	3 11	3 26	9
10	1 47	1 33	1 23	1 20	1 18	1 19	1 20	1 25	1 34	1 45	1 57	2 9	2 21	2 34	2 46	2 59	10
11	1 57	1 41	1 28	1 23	1 19	1 17	1 18	1 21	1 27	1 36	1 46	1 56	2 6	2 17	2 28	2 39	11
12	2 9	1 50	1 34	1 27	1 22	1 19	1 17	1 19	1 23	1 29	1 37	1 46	1 55	2 4	2 13	2 23	12
13	2 21	1 59	1 41	1 32	1 26	1 21	1 18	1 17	1 20	1 24	1 30	1 37	1 45	1 53	2 1	2 9	13
14	2 34	2 8	1 50	1 38	1 30	1 24	1 20	1 16	1 18	1 21	1 25	1 30	1 36	1 43	1 51	1 58	14
15	2 47	2 18	1 59	1 45	1 35	1 28	1 22	1 17	1 16	1 18	1 21	1 25	1 30	1 35	1 42	1 49	15
16	2 59	2 28	2 7	1 52	1 41	1 32	1 25	1 19	1 15	1 16	1 18	1 21	1 25	1 29	1 35	1 41	16
17	3 12	2 38	2 16	1 59	1 47	1 36	1 28	1 21	1 16	1 15	1 16	1 18	1 21	1 25	1 30	1 35	17
18	3 25	2 48	2 25	2 7	1 52	1 41	1 32	1 23	1 17	1 14	1 15	1 17	1 19	1 22	1 25	1 29	18
19	3 38	2 58	2 34	2 14	1 58	1 46	1 36	1 25	1 18	1 15	1 14	1 15	1 17	1 19	1 22	1 25	19
20	3 50	3 9	2 43	2 21	2 4	1 51	1 40	1 27	1 20	1 16	1 13	1 14	1 15	1 17	1 19	1 21	20
21	4 3	3 19	2 52	2 28	2 10	1 56	1 45	1 30	1 22	1 17	1 14	1 13	1 14	1 15	1 16	1 18	21
22	4 15	3 30	3 0	2 35	2 17	2 2	1 50	1 33	1 24	1 18	1 14	1 11	1 12	1 13	1 14	1 16	22
23	4 28	3 40	3 9	2 42	2 24	2 7	1 55	1 36	1 26	1 19	1 15	1 12	1 11	1 12	1 13	1 14	23
24	4 40	3 51	3 17	2 50	2 30	2 13	1 59	1 39	1 28	1 21	1 16	1 12	1 10	1 11	1 11	1 12	24
25	4 52	4 1	3 26	2 57	2 36	2 18	2 4	1 42	1 30	1 22	1 17	1 13	1 11	1 10	1 10	1 10	25
26	5 4	4 12	3 34	3 5	2 43	2 24	2 8	1 46	1 32	1 24	1 18	1 13	1 11	1 9	1 9	1 9	26
27	5 16	4 22	3 43	3 12	2 50	2 30	2 13	1 50	1 34	1 26	1 19	1 14	1 11	1 9	1 8	1 8	27
28	5 28	4 33	3 52	3 20	2 57	2 35	2 17	1 53	1 37	1 27	1 20	1 15	1 11	1 9	1 7	1 8	28
29	5 41	4 44	4 1	3 28	3 3	2 41	2 21	1 57	1 40	1 29	1 21	1 16	1 12	1 10	1 8	1 7	29
30	5 53	4 54	4 10	3 35	3 9	2 46	2 26	2 0	1 43	1 31	1 23	1 17	1 13	1 10	1 8	1 6	30
31	6 5	5 4	4 19	3 42	3 15	2 52	2 31	2 4	1 46	1 33	1 24	1 18	1 13	1 10	1 8	1 6	31
32	6 17	5 14	4 27	3 49	3 21	2 57	2 36	2 8	1 49	1 36	1 26	1 19	1 14	1 11	1 9	1 7	32
33	6 29	5 23	4 35	3 56	3 27	3 2	2 41	2 12	1 52	1 38	1 27	1 20	1 15	1 11	1 9	1 7	33
34	6 40	5 32	4 43	4 3	3 32	3 7	2 46	2 15	1 55	1 40	1 29	1 21	1 16	1 12	1 9	1 7	34
35	6 50	5 40	4 50	4 9	3 38	3 12	2 50	2 19	1 58	1 43	1 31	1 22	1 17	1 13	1 9	1 7	35
36	6 59	5 48	4 57	4 15	3 43	3 16	2 54	2 22	2 1	1 45	1 32	1 23	1 18	1 13	1 10	1 7	36
37	7 7	5 56	5 4	4 21	3 49	3 21	2 59	2 25	2 4	1 47	1 34	1 24	1 19	1 14	1 10	1 7	37
38	7 15	6 3	5 10	4 29	3 54	3 25	3 3	2 28	2 6	1 49	1 35	1 25	1 19	1 14	1 10	1 7	38
39	7 22	6 10	5 16	4 33	3 59	3 30	3 7	2 31	2 8	1 51	1 36	1 26	1 20	1 15	1 10	1 7	39
40		6 17	5 21	4 38	4 4	3 34	3 11	2 34	2 10	1 52	1 38	1 27	1 20	1 15	1 11	1 8	40
41			5 26	4 43	4 8	3 38	3 15	2 36	2 13	1 54	1 39	1 28	1 21	1 16	1 12	1 8	41
42				4 47	4 12	3 42	3 18	2 39	2 16	1 56	1 41	1 29	1 22	1 16	1 12	1 8	42
43					4 16	3 46	3 21	2 42	2 18	1 58	1 42	1 30	1 22	1 16	1 12	1 8	43
44						3 50	3 24	2 45	2 20	2 0	1 43	1 31	1 23	1 17	1 12	1 8	44
46							3 27	2 50	2 23	2 2	1 45	1 32	1 24	1 17	1 12	1 8	46
48								2 54	2 26	2 4	1 47	1 34	1 25	1 18	1 12	1 8	48
50									2 29	2 6	1 49	1 36	1 26	1 19	1 13	1 8	50
52										2 8	1 51	1 38	1 28	1 19	1 13	1 8	52
54											1 53	1 39	1 29	1 20	1 14	1 8	54
56												1 40	1 30	1 21	1 14	1 8	56
58													1 30	1 21	1 14	1 8	58
60														1 21	1 14	1 8	60
62															1 14	1 8	62
64																1 8	64
66																	66
68																	68
70																	70
72																	72
74																	74
76																	76
78																	78
80																	80
82																	82
84																	84
86																	86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 32°.

☽'s App. Alt.	*Apparent Altitude of the Sun, Star or Planet.*																☽'s App. Alt.
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	
°	′ ″	′ ″	′ ″	′ ″	″	′ ″	′ ″	′ ″	′ ′	′ ″	′ ″	′ ′	′ ′	′ ″	. ′	′ ″	°
6	6 10	6 33	6 55	7 15													6
7	5 7	5 26	5 44	6 2													7
8	4 20	4 37	4 52	5 7	5 35												8
9	3 41	3 56	4 10	4 24	4 50												9
10	3 12	3 25	3 38	3 50	4 12												10
11	2 51	3 2	3 13	3 23	3 42												11
12	2 33	2 43	2 51	3 00	3 17	3 33											12
13	2 18	2 26	2 34	2 42	2 56	3 9											13
14	2 5	2 12	2 19	2 27	2 39	2 50											14
15	1 55	2 2	2 8	2 14	2 25	2 35											15
16	1 47	1 53	1 58	2 3	2 13	2 22	2 30										16
17	1 40	1 45	1 50	1 54	2 2	2 11	2 18										17
18	1 34	1 38	1 42	1 46	1 53	2 0	2 7										18
19	1 29	1 33	1 36	1 39	1 45	1 51	1 57										19
20	1 25	1 28	1 31	1 33	1 38	1 43	1 49	1 54									20
21	1 21	1 24	1 26	1 28	1 32	1 37	1 42	1 46									21
22	1 18	1 20	1 22	1 24	1 27	1 31	1 35	1 39									22
23	1 15	1 17	1 19	1 20	1 23	1 27	1 30	1 34									23
24	1 13	1 14	1 16	1 17	1 20	1 23	1 26	1 29	1 32								24
25	1 11	1 12	1 13	1 15	1 17	1 19	1 21	1 24	1 26								25
26	1 9	1 10	1 11	1 12	1 14	1 16	1 17	1 19	1 21								26
27	1 8	1 9	1 9	1 10	1 12	1 13	1 14	1 16	1 17								27
28	1 8	1 8	1 8	1 9	1 10	1 11	1 12	1 13	1 14	1 15							28
29	1 7	1 7	1 7	1 7	1 8	1 9	1 9	1 10	1 11	1 11							29
30	1 6	1 6	1 6	1 6	1 6	1 7	1 7	1 7	1 8	1 8							30
31	1 6	1 6	1 6	1 5	1 5	1 5	1 5	1 5	1 5	1 5							31
32	1 6	1 5	1 5	1 4	1 4	1 4	1 4	1 4	1 3	1 3	1 3						32
33	1 5	1 4	1 4	1 3	1 3	1 2	1 2	1 2	1 1	1 1	1 1						33
34	1 5	1 4	1 3	1 2	1 2	1 1	1 0	1 0	59	59	59						34
35	1 5	1 3	1 3	1 2	1 1	1 0	59	58	57	57	57						35
36	1 5	1 3	1 2	1 1	1 1	1 0	58	57	56	56	55	54					36
37	1 5	1 3	1 1	1 0	1 0	59	57	56	55	55	54	53					37
38	1 5	1 3	1 1	1 0	59	58	56	55	54	54	53	52					38
39	1 5	1 3	1 1	59	58	57	56	54	53	52	51	50					39
40	1 5	1 2	1 0	59	58	56	55	53	52	51	50	49	48				40
41	1 5	1 2	1 0	59	58	56	54	52	51	50	49	48	47				41
42	1 5	1 2	1 0	59	57	55	53	51	50	49	48	47	47				42
43	1 5	1 2	1 0	58	56	54	52	51	49	48	47	47	46	45			43
44	1 5	1 2	1 0	58	55	53	51	50	49	48	47	46	45	44			44
46	1 5	1 2	1 0	58	55	52	51	50	48	47	46	45	44	43			46
48	1 5	1 2	59	57	55	52	50	49	47	46	45	44	43	42	41		48
50	1 5	1 2	59	57	54	51	49	48	47	46	44	43	42	41	40		50
52	1 4	1 1	58	56	53	51	49	47	46	45	43	42	41	40	39	38	52
54	1 4	1 1	58	56	53	50	48	46	45	44	42	41	40	39	38	37	54
56	1 4	1 1	58	56	52	49	47	45	44	42	41	40	39	38	37	36	56
58	1 4	1 1	58	56	52	49	47	45	43	41	40	39	38	37	36	35	58
60	1 4	1 0	57	55	51	48	46	44	42	40	39	38	37	36	35	35	60
62	1 3	59	56	54	51	48	45	43	41	39	38	37	36	35	34	34	62
64	1 3	59	56	54	50	47	45	43	41	38	38	37	36	35	34	33	64
66	1 3	59	56	54	50	47	44	42	40	38	37	36	35	34	33		66
68		59	55	53	48	46	44	42	40	38	37	36	35	34	33		68
70			55	52	48	45	43	41	39	37	36	35	34	33			70
72				52	47	44	42	40	38	37	36	35	33	32			72
74					47	44	42	40	38	36	35	34	32				74
76					47	43	41	39	38	36	35	34	32				76
78						43	41	39	37	35	34	33					78
80						43	41	39	37	35	34	33					80
82							40	38	36	34	33						82
84							39	38	36	34	33						84
86								37	35	34							86
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 36°.

☽'s App. Alt.	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	☽'s App. Alt.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ′	′ ″	°
6	1 17	1 19	1 22	1 27	1 33	1 42	1 52	2 13	2 34	2 56	3 19	3 43	4 7	4 31	4 55	5 18	6
7	1 20	1 17	1 19	1 22	1 26	1 31	1 37	1 52	2 10	2 28	2 48	3 8	3 27	3 46	4 6	4 25	7
8	1 25	1 20	1 17	1 19	1 21	1 23	1 27	1 39	1 53	2 8	2 24	2 40	2 57	3 14	3 30	3 46	8
9	1 32	1 24	1 19	1 17	1 18	1 19	1 21	1 29	1 40	1 52	2 5	2 19	2 33	2 47	3 2	3 16	9
10	1 42	1 30	1 23	1 19	1 16	1 17	1 18	1 23	1 31	1 40	1 51	2 2	2 14	2 27	2 40	2 52	10
11	1 52	1 37	1 28	1 22	1 18	1 16	1 17	1 19	1 25	1 33	1 42	1 51	2 1	2 12	2 23	2 33	11
12	2 3	1 45	1 34	1 26	1 20	1 17	1 15	1 17	1 21	1 27	1 34	1 41	1 50	1 59	2 8	2 17	12
13	2 14	1 53	1 40	1 30	1 23	1 19	1 16	1 15	1 18	1 23	1 28	1 34	1 41	1 49	1 57	2 5	13
14	2 25	2 1	1 47	1 35	1 26	1 21	1 18	1 14	1 16	1 19	1 24	1 29	1 35	1 41	1 49	1 55	14
15	2 36	2 10	1 54	1 41	1 30	1 25	1 21	1 16	1 15	1 17	1 21	1 25	1 30	1 35	1 41	1 46	15
16	2 48	2 20	2 2	1 47	1 35	1 29	1 24	1 18	1 13	1 15	1 18	1 21	1 25	1 29	1 34	1 39	16
17	3 0	2 30	2 10	1 53	1 40	1 33	1 28	1 20	1 15	1 14	1 16	1 18	1 21	1 24	1 28	1 33	17
18	3 12	2 40	2 18	2 0	1 46	1 38	1 32	1 22	1 16	1 13	1 15	1 16	1 18	1 20	1 23	1 27	18
19	3 24	2 49	2 27	2 7	1 51	1 43	1 36	1 25	1 18	1 15	1 14	1 15	1 16	1 18	1 20	1 23	19
20	3 35	2 59	2 35	2 14	1 57	1 48	1 40	1 28	1 21	1 16	1 12	1 13	1 14	1 16	1 18	1 20	20
21	3 46	3 9	2 43	2 21	2 3	1 53	1 44	1 31	1 23	1 17	1 13	1 12	1 13	1 14	1 16	1 18	21
22	3 57	3 18	2 51	2 28	2 9	1 58	1 48	1 34	1 25	1 18	1 14	1 11	1 12	1 13	1 14	1 15	22
23	4 9	3 28	2 59	2 35	2 16	2 3	1 52	1 36	1 26	1 19	1 14	1 11	1 10	1 11	1 12	1 13	23
24	4 20	3 37	3 7	2 42	2 22	2 8	1 56	1 39	1 28	1 20	1 15	1 11	1 9	1 9	1 10	1 11	24
25	4 32	3 47	3 15	2 49	2 28	2 13	2 0	1 42	1 30	1 22	1 15	1 11	1 9	1 8	1 8	1 9	25
26	4 43	3 56	3 23	2 56	2 34	2 18	2 4	1 45	1 32	1 23	1 16	1 12	1 9	1 7	1 7	1 7	26
27	4 55	4 6	3 31	3 3	2 40	2 23	2 9	1 48	1 35	1 25	1 17	1 12	1 9	1 7	1 6	1 6	27
28	5 6	4 15	3 39	3 10	2 46	2 28	2 13	1 52	1 38	1 27	1 19	1 13	1 9	1 7	1 6	1 6	28
29	5 17	4 25	3 47	3 17	2 52	2 34	2 18	1 56	1 40	1 29	1 20	1 13	1 9	1 7	1 6	1 5	29
30	5 28	4 34	3 54	3 24	2 58	2 39	2 23	2 0	1 43	1 31	1 21	1 14	1 10	1 8	1 6	1 5	30
31	5 39	4 43	4 2	3 31	3 4	2 44	2 28	2 4	1 46	1 33	1 23	1 16	1 11	1 8	1 6	1 5	31
32	5 49	4 52	4 10	3 37	3 10	2 49	2 33	2 7	1 49	1 35	1 25	1 17	1 12	1 9	1 7	1 5	32
33	5 59	5 0	4 18	3 44	3 16	2 54	2 37	2 10	1 51	1 37	1 27	1 19	1 14	1 10	1 7	1 5	33
34	6 9	5 8	4 25	3 50	3 22	2 59	2 41	2 13	1 53	1 39	1 29	1 21	1 15	1 11	1 8	1 6	34
35	6 19	5 16	4 32	3 56	3 28	3 4	2 46	2 16	1 56	1 41	1 30	1 22	1 16	1 11	1 8	1 6	35
36	6 28	5 24	4 38	4 2	3 33	3 9	2 50	2 19	1 59	1 43	1 32	1 23	1 17	1 12	1 9	1 6	36
37	6 38	5 32	4 45	4 8	3 39	3 14	2 54	2 22	2 1	1 45	1 33	1 24	1 18	1 13	1 9	1 6	37
38	6 47	5 40	4 52	4 14	3 44	3 18	2 58	2 25	2 4	1 47	1 35	1 26	1 19	1 14	1 10	1 6	38
39	6 57	5 48	4 59	4 20	3 49	3 23	3 2	2 28	2 6	1 49	1 36	1 27	1 20	1 14	1 10	1 7	39
40	7 6	5 56	5 5	4 25	3 54	3 27	3 6	2 31	2 8	1 51	1 38	1 28	1 21	1 15	1 11	1 7	40
41	7 16	6 4	5 12	4 31	3 59	3 31	3 10	2 33	2 11	1 53	1 40	1 30	1 22	1 15	1 11	1 8	41
42	7 25	6 12	5 18	4 36	4 3	3 35	3 13	2 36	2 14	1 55	1 42	1 31	1 22	1 16	1 11	1 8	42
43	7 33	6 19	5 24	4 41	4 8	3 39	3 17	2 39	2 16	1 57	1 43	1 32	1 23	1 16	1 11	1 8	43
44		6 26	5 30	4 46	4 12	3 43	3 20	2 42	2 18	1 59	1 45	1 33	1 24	1 17	1 12	1 9	44
46			5 41	4 55	4 20	3 50	3 26	2 47	2 22	2 2	1 47	1 35	1 25	1 18	1 13	1 9	46
48					4 27	3 57	3 32	2 52	2 26	2 5	1 49	1 37	1 27	1 20	1 14	1 10	48
50							3 38	2 57	2 30	2 8	1 51	1 39	1 29	1 21	1 15	1 10	50
52								3 1	2 33	2 11	1 53	1 41	1 31	1 22	1 16	1 11	52
54									2 36	2 13	1 55	1 43	1 32	1 23	1 16	1 11	54
56										2 15	1 57	1 44	1 33	1 24	1 17	1 11	56
58											1 59	1 45	1 34	1 25	1 18	1 12	58
60												1 46	1 35	1 26	1 18	1 12	60
62													1 36	1 26	1 18	1 12	62
64														1 26	1 19	1 12	64
66															1 19	1 13	66
68																1 13	68
70																	70
72																	72
74																	74
76																	76
78																	78
80																	80
82																	82
84																	84
86																	86
						11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Table P. Effect of Sun's Par.

Add the Numbers above the lines to Third Correction; subtract the others.

☽'s App. Alt.	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	0	1	3	5	7					
10	1	0	2	4	5					
20	4	3	1	1	3	4				
30	6	5	3	1	0	2	3			
40	9	8	5	3	2	0	1	2		
50			7	6	4	2	1	0	1	
60				7	5	4	3	2	1	0
70					6	3	4	3	2	
80						6	4			

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 36°.

☽'s App Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ′	′ ′	′ ″	′ ′	°
6	5 40	6 1	6 22	6 43	7 24												6
7	4 43	5 1	5 19	5 36	6 11												7
8	4 1	4 16	4 31	4 46	5 16	5 45											8
9	3 29	3 42	3 55	4 8	4 33	4 58											9
10	3 4	3 16	3 27	3 38	3 59	4 20											10
11	2 43	2 54	3 4	3 13	3 32	3 50											11
12	2 27	2 36	2 45	2 53	3 10	3 25	3 40										12
13	2 13	2 21	2 29	2 37	2 51	3 4	3 16										13
14	2 2	2 9	2 16	2 23	2 36	2 47	2 57										14
15	1 53	1 59	2 5	2 11	2 23	2 33	2 42										15
16	1 45	1 50	1 56	2 1	2 12	2 21	2 29	2 36									16
17	1 38	1 42	1 47	1 53	2 2	2 10	2 17	2 24									17
18	1 32	1 36	1 40	1 45	1 53	2 1	2 7	2 13									18
19	1 27	1 30	1 34	1 38	1 45	1 52	1 58	2 3									19
20	1 23	1 26	1 29	1 33	1 38	1 44	1 49	1 54	1 58								20
21	1 20	1 22	1 25	1 28	1 33	1 38	1 43	1 47	1 51								21
22	1 17	1 18	1 20	1 23	1 28	1 33	1 37	1 41	1 45								22
23	1 14	1 15	1 17	1 19	1 24	1 28	1 32	1 36	1 39								23
24	1 11	1 12	1 14	1 16	1 20	1 23	1 27	1 31	1 34	1 37							24
25	1 9	1 10	1 11	1 13	1 16	1 19	1 22	1 26	1 29	1 31							25
26	1 8	1 8	1 9	1 11	1 13	1 15	1 18	1 21	1 24	1 26							26
27	1 7	1 7	1 8	1 9	1 11	1 13	1 15	1 17	1 20	1 22							27
28	1 6	1 6	1 7	1 8	1 9	1 11	1 12	1 14	1 16	1 18	1 20						28
29	1 6	1 6	1 6	1 7	1 8	1 9	1 10	1 11	1 13	1 14	1 16						29
30	1 5	1 5	1 5	1 6	1 7	1 7	1 8	1 9	1 10	1 11	1 13						30
31	1 5	1 5	1 5	1 5	1 6	1 6	1 6	1 7	1 8	1 9	1 10						31
32	1 4	1 4	1 5	1 5	1 5	1 5	1 5	1 5	1 6	1 7	1 8	1 9					32
33	1 4	1 4	1 4	1 4	1 4	1 4	1 4	1 4	1 4	1 5	1 5	1 6					33
34	1 4	1 3	1 3	1 3	1 3	1 3	1 3	1 3	1 3	1 3	1 3	1 3					34
35	1 4	1 3	1 3	1 3	1 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1					35
36	1 4	1 3	1 2	1 2	1 1	1 0	1 0	1 0	1 0	1 0	1 0	1 0	1 0				36
37	1 4	1 3	1 2	1 1	59	59	59	59	59	59	59	59	58				37
38	1 4	1 3	1 1	1 0	58	58	58	58	58	58	58	58	57				38
39	1 5	1 3	1 1	1 0	58	58	58	58	57	57	57	56	56				39
40	1 5	1 3	1 1	1 0	58	57	57	57	57	56	56	55	54	53			40
41	1 6	1 3	1 1	59	57	56	56	56	56	55	54	53	52	52			41
42	1 6	1 3	1 1	59	57	56	55	55	55	54	53	52	51	51			42
43	1 6	1 3	1 1	59	56	55	54	54	54	53	52	51	50	50	49		43
44	1 6	1 3	1 1	59	56	54	53	53	53	52	51	50	49	49	48		44
46	1 6	1 3	1 1	59	56	54	53	52	51	50	49	48	48	47	47		46
48	1 7	1 3	1 1	59	56	54	52	51	49	48	47	46	46	45	45	45	48
50	1 7	1 3	1 1	59	56	53	51	50	48	47	46	45	45	44	44	44	50
52	1 7	1 3	1 1	59	55	52	50	49	48	47	46	45	44	43	42	42	52
54	1 7	1 3	1 1	59	55	52	50	48	47	46	45	44	43	42	41	41	54
56	1 7	1 3	1 0	58	55	52	49	48	47	46	45	44	43	42	41	40	56
58	1 7	1 3	1 0	58	55	52	49	47	46	45	44	43	42	41	40	39	58
60	1 7	1 3	1 0	58	55	51	48	46	45	44	43	42	41	40	39	38	60
62	1 7	1 3	1 0	58	54	51	48	46	44	43	42	41	40	39	38		62
64	1 7	1 3	1 0	58	54	51	48	46	44	43	42	40	39	38	37		64
66	1 8	1 3	1 0	57	54	50	47	45	43	42	41	39	38	37			66
68	1 8	1 3	1 0	57	54	50	47	45	43	42	40	39	38	37			68
70	1 8	1 3	1 0	57	53	50	47	44	42	41	40	39	38				70
72		1 3	1 0	57	53	50	46	43	41	40	39	38					72
74			1 0	57	52	49	46	43	41	40	39	38					74
76				57	52	48	45	43	41	39	38	37					76
78					51	48	45	42	40	39	37						78
80					51	47	44	42	40	39	37						80
82						47	44	41	40	38							82
84						47	44	41	39	38							84
86							44	41	39								86
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 40°.

☽'s App Alt.	*Apparent Altitude of the Sun, Star or Planet.*																☽'s App Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	″	″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 16	1 18	1 21	1 25	1 31	1 39	1 47	2 5	2 26	2 48	3 10	3 32	3 54	4 16	4 38	4 59	6
7	1 19	1 16	1 18	1 21	1 24	1 28	1 34	1 48	2 4	2 22	2 40	2 58	3 16	3 34	3 52	4 10	7
8	1 24	1 19	1 16	1 18	1 20	1 22	1 26	1 36	1 50	2 4	2 18	2 33	2 48	3 4	3 20	3 36	8
9	1 31	1 23	1 19	1 16	1 18	1 19	1 21	1 27	1 38	1 49	2 1	2 13	2 25	2 38	2 52	3 5	9
10	1 40	1 29	1 23	1 19	1 16	1 17	1 18	1 21	1 29	1 38	1 48	1 58	2 9	2 20	2 32	2 44	10
11	1 50	1 36	1 28	1 22	1 18	1 15	1 16	1 18	1 23	1 31	1 39	1 48	1 57	2 7	2 17	2 27	11
12	2 1	1 44	1 34	1 26	1 20	1 17	1 15	1 17	1 20	1 26	1 33	1 40	1 48	1 57	2 5	2 13	12
13	2 11	1 52	1 40	1 30	1 23	1 19	1 16	1 16	1 18	1 22	1 28	1 34	1 41	1 48	1 55	2 2	13
14	2 21	2 0	1 46	1 34	1 26	1 21	1 17	1 15	1 17	1 19	1 23	1 28	1 34	1 40	1 46	1 53	14
15	2 31	2 8	1 52	1 39	1 30	1 23	1 19	1 16	1 15	1 17	1 20	1 23	1 27	1 32	1 38	1 44	15
16	2 41	2 16	1 58	1 44	1 34	1 26	1 21	1 17	1 14	1 15	1 17	1 19	1 22	1 26	1 31	1 37	16
17	2 52	2 24	2 4	1 49	1 38	1 30	1 24	1 19	1 15	1 14	1 15	1 17	1 19	1 22	1 26	1 31	17
18	3 3	2 32	2 11	1 54	1 43	1 34	1 28	1 21	1 16	1 13	1 14	1 15	1 17	1 19	1 22	1 26	18
19	3 14	2 41	2 18	2 0	1 48	1 39	1 32	1 23	1 17	1 14	1 13	1 14	1 15	1 17	1 19	1 22	19
20	3 25	2 50	2 25	2 6	1 53	1 43	1 36	1 25	1 19	1 15	1 12	1 12	1 13	1 15	1 16	1 19	20
21	3 36	2 59	2 32	2 12	1 58	1 47	1 39	1 27	1 20	1 16	1 13	1 11	1 12	1 13	1 14	1 16	21
22	3 47	3 8	2 40	2 18	2 4	1 52	1 43	1 30	1 22	1 17	1 13	1 11	1 11	1 12	1 13	1 14	22
23	3 58	3 17	2 48	2 25	2 10	1 57	1 47	1 33	1 24	1 18	1 14	1 12	1 10	1 10	1 11	1 12	23
24	4 9	3 26	2 56	2 32	2 15	2 2	1 51	1 37	1 26	1 19	1 15	1 12	1 9	1 9	1 9	1 10	24
25	4 20	3 35	3 4	2 39	2 21	2 7	1 56	1 40	1 28	1 21	1 16	1 13	1 10	1 8	1 8	1 9	25
26	4 30	3 44	3 12	2 45	2 27	2 12	2 0	1 43	1 30	1 22	1 17	1 13	1 10	1 8	1 8	1 9	26
27	4 41	3 53	3 20	2 52	2 33	2 17	2 4	1 47	1 33	1 24	1 18	1 14	1 11	1 8	1 7	1 8	27
28	4 51	4 2	3 28	2 59	2 39	2 23	2 8	1 50	1 35	1 25	1 19	1 14	1 11	1 8	1 7	1 7	28
29	5 1	4 11	3 36	3 6	2 45	2 28	2 12	1 53	1 38	1 27	1 20	1 15	1 12	1 9	1 7	1 7	29
30	5 12	4 20	3 44	3 13	2 50	2 33	2 17	1 56	1 40	1 29	1 21	1 15	1 12	1 9	1 7	1 6	30
31	5 23	4 29	3 52	3 20	2 56	2 38	2 21	2 0	1 43	1 30	1 22	1 16	1 12	1 9	1 7	1 6	31
32	5 33	4 38	3 59	3 27	3 1	2 43	2 26	2 3	1 45	1 32	1 23	1 17	1 13	1 10	1 7	1 6	32
33	5 43	4 46	4 6	3 33	3 7	2 48	2 30	2 6	1 47	1 34	1 24	1 18	1 14	1 10	1 8	1 6	33
34	5 52	4 54	4 13	3 39	3 13	2 53	2 34	2 9	1 49	1 36	1 26	1 19	1 15	1 11	1 8	1 6	34
35	6 1	5 2	4 20	3 45	3 19	2 58	2 38	2 12	1 51	1 38	1 27	1 20	1 15	1 11	1 8	1 6	35
36	6 10	5 10	4 26	3 51	3 24	3 2	2 42	2 15	1 54	1 40	1 29	1 22	1 16	1 12	1 8	1 6	36
37	6 18	5 17	4 32	3 57	3 29	3 7	2 46	2 18	1 57	1 42	1 31	1 23	1 17	1 12	1 9	1 7	37
38	6 26	5 24	4 38	4 3	3 33	3 11	2 50	2 21	2 0	1 44	1 33	1 25	1 18	1 13	1 9	1 7	38
39	6 34	5 31	4 44	4 8	3 38	3 15	2 54	2 24	2 2	1 46	1 35	1 26	1 19	1 14	1 10	1 7	39
40	6 42	5 38	4 50	4 13	3 42	3 19	2 58	2 27	2 5	1 48	1 37	1 28	1 20	1 14	1 10	1 7	40
41	6 50	5 45	4 56	4 19	3 47	3 24	3 2	2 30	2 8	1 51	1 39	1 29	1 21	1 15	1 11	1 8	41
42	6 58	5 52	5 2	4 24	3 51	3 28	3 6	2 33	2 10	1 53	1 41	1 30	1 22	1 16	1 11	1 8	42
43	7 7	5 59	5 8	4 29	3 56	3 32	3 10	2 36	2 13	1 55	1 43	1 32	1 23	1 17	1 12	1 9	43
44	7 16	6 6	5 14	4 34	4 0	3 36	3 13	2 39	2 15	1 57	1 44	1 33	1 24	1 18	1 13	1 9	44
46	7 33	6 21	5 26	4 44	4 9	3 44	3 20	2 44	2 19	2 1	1 47	1 35	1 27	1 20	1 14	1 10	46
48	7 50	6 35	5 38	4 54	4 18	3 51	3 27	2 49	2 23	2 5	1 50	1 37	1 29	1 22	1 15	1 11	48
50			5 50	5 3	4 27	3 58	3 33	2 54	2 27	2 8	1 52	1 39	1 31	1 23	1 17	1 12	50
52					4 36	4 5	3 39	2 59	2 31	2 11	1 54	1 42	1 32	1 24	1 18	1 13	52
54							3 45	3 4	2 35	2 14	1 56	1 44	1 34	1 26	1 19	1 14	54
56								3 9	2 39	2 17	1 58	1 46	1 36	1 28	1 20	1 14	56
58									2 43	2 19	2 0	1 48	1 37	1 29	1 21	1 15	58
60										2 21	2 2	1 49	1 38	1 30	1 22	1 15	60
62											2 4	1 50	1 39	1 30	1 22	1 16	62
64												1 51	1 40	1 31	1 23	1 16	64
66													1 40	1 31	1 24	1 17	66
68														1 31	1 24	1 17	68
70															1 24	1 17	70
72																1 17	72
74																	74
76																	76
78																	78
80																	80
82																	82
84																	84
86																	86
						11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Table P. Effect of Sun's Par.

Add the Numbers above the lines to Third Correction; subtract the others.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	0	1	2	4	6					
10	1	0	1	3	4	6				
20	4	3	1	1	3	3	4			
30	6	5	3	2	0	1	2	3		
40	8	7	5	4	2	1	0	1	2	
50		9	7	5	4	2	1	0	0	0
60			9	7	5	4	3	2	2	
70				8	6	5	4	3		
80					7	6	4			
90						6				

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 40°.

☽'s App. Alt.	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	☽'s App. Alt.
	Apparent Altitude of the Sun, Star or Planet.																
°	′ ″	′ ″	′ ″	″	′ ″	′ ″	′ ″	′		′ ″	′ ″	′	′ ′	′ ″	′ ′	′ ″	°
6	5 19	5 39	5 59	6 19	6 57	7 33											6
7	4 27	4 44	5 1	5 18	5 51	6 20											7
8	3 51	4 6	4 20	4 34	5 1	5 26	5 50										8
9	3 20	3 34	3 46	3 58	4 22	4 44	5 5										9
10	2 56	3 8	3 19	3 30	3 50	4 9	4 27										10
11	2 37	2 47	2 57	3 6	3 25	3 42	3 58										11
12	2 22	2 30	2 39	2 48	3 5	3 20	3 33	3 46									12
13	2 10	2 17	2 25	2 32	2 47	3 1	3 13	3 25									13
14	2 0	2 6	2 12	2 18	2 32	2 44	2 55	3 4									14
15	1 50	1 56	2 1	2 7	2 19	2 30	2 40	2 48									15
16	1 42	1 47	1 52	1 58	2 8	2 18	2 27	2 35	2 42								16
17	1 36	1 40	1 45	1 50	1 59	2 8	2 16	2 23	2 30								17
18	1 31	1 34	1 38	1 43	1 51	1 59	2 6	2 12	2 19								18
19	1 26	1 29	1 33	1 36	1 44	1 51	1 58	2 3	2 9								19
20	1 22	1 24	1 27	1 30	1 37	1 44	1 50	1 55	2 0	2 5							20
21	1 18	1 20	1 23	1 26	1 32	1 38	1 44	1 49	1 53	1 57							21
22	1 15	1 17	1 19	1 22	1 28	1 33	1 38	1 43	1 47	1 50							22
23	1 13	1 14	1 16	1 19	1 24	1 29	1 33	1 38	1 42	1 45							23
24	1 11	1 12	1 14	1 16	1 21	1 25	1 29	1 33	1 37	1 40	1 43						24
25	1 10	1 11	1 12	1 14	1 18	1 21	1 25	1 29	1 32	1 35	1 37						25
26	1 9	1 10	1 11	1 12	1 15	1 18	1 21	1 25	1 28	1 30	1 32						26
27	1 8	1 9	1 9	1 10	1 13	1 15	1 18	1 21	1 24	1 26	1 27						27
28	1 7	1 8	1 8	1 9	1 11	1 13	1 16	1 18	1 20	1 22	1 23	1 24					28
29	1 7	1 7	1 7	1 8	1 9	1 11	1 13	1 15	1 16	1 18	1 19	1 20					29
30	1 6	1 6	1 6	1 7	1 8	1 9	1 11	1 12	1 13	1 15	1 16	1 17					30
31	1 6	1 6	1 6	1 7	1 7	1 8	1 9	1 10	1 11	1 13	1 14	1 15					31
32	1 6	1 6	1 6	1 6	1 6	1 6	1 7	1 8	1 9	1 10	1 11	1 12	1 13				32
33	1 5	1 5	1 5	1 5	1 5	1 5	1 6	1 6	1 7	1 8	1 9	1 10	1 10				33
34	1 5	1 4	1 4	1 4	1 4	1 4	1 5	1 5	1 6	1 7	1 7	1 8	1 8				34
35	1 5	1 4	1 4	1 4	1 4	1 4	1 4	1 4	1 4	1 5	1 5	1 6	1 6				35
36	1 5	1 4	1 3	1 3	1 3	1 3	1 3	1 3	1 3	1 4	1 4	1 4	1 4	1 4			36
37	1 5	1 4	1 3	1 2	1 2	1 2	1 2	1 1	1 1	1 2	1 2	1 2	1 2	1 2			37
38	1 5	1 4	1 2	1 1	1 1	1 1	1 1	1 0	1 0	1 0	1 0	1 1	1 1	1 1			38
39	1 5	1 4	1 2	1 1	1 0	1 0	1 0	59	59	59	59	59	59	59			39
40	1 5	1 4	1 2	1 1	1 0	59	59	58	58	57	57	57	57	57	57		40
41	1 6	1 4	1 2	1 1	59	58	58	57	57	56	56	56	56	56	56		41
42	1 6	1 4	1 2	1 0	58	57	57	56	56	55	55	55	55	55	55		42
43	1 6	1 4	1 2	1 0	58	57	56	55	55	54	54	54	54	54	54	54	43
44	1 6	1 4	1 2	1 0	58	56	55	54	54	53	53	53	53	53	53	53	44
46	1 7	1 4	1 2	1 0	58	56	54	53	53	52	52	51	51	51	51	51	46
48	1 8	1 5	1 2	1 0	58	55	53	52	52	51	51	50	49	49	49	49	48
50	1 8	1 5	1 2	1 0	57	54	52	51	51	50	49	48	48	48	48	48	50
52	1 9	1 5	1 2	1 0	57	54	52	50	50	49	48	47	47	46	46	46	52
54	1 9	1 5	1 2	1 0	57	54	51	49	49	48	47	46	46	45	45	45	54
56	1 10	1 6	1 3	1 0	56	53	51	49	48	47	46	45	45	44	44	44	56
58	1 10	1 6	1 3	1 0	56	53	50	48	47	46	45	45	44	43	43		58
60	1 10	1 7	1 4	1 1	56	52	50	48	47	45	44	44	43	42	42		60
62	1 11	1 7	1 4	1 1	56	52	50	48	46	45	44	43	42	42			62
64	1 11	1 7	1 4	1 1	56	52	49	47	45	44	43	42	41	41			64
66	1 12	1 7	1 4	1 1	56	52	49	47	45	43	42	42	41				66
68	1 12	1 8	1 4	1 1	56	52	49	47	45	43	42	42	41				68
70	1 12	1 8	1 4	1 1	55	51	48	46	44	43	42	42					70
72	1 13	1 8	1 4	1 1	55	51	48	46	44	43	42	41					72
74	1 13	1 8	1 4	1 1	55	51	48	46	44	43	42						74
76		1 8	1 4	1 1	55	51	48	46	44	42	41						76
78			1 4	1 1	55	51	48	46	43	42							78
80				1 1	55	51	48	46	43	41							80
82					55	51	48	46	43								82
84					55	51	48	46	43								84
86						51	48	45									86
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 44°.

Apparent Altitude of the Sun, Star or Planet.

D's App. Alt.	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	D's App. Alt.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 16	1 18	1 21	1 25	1 31	1 37	1 45	2 3	2 23	2 44	3 5	3 25	3 45	4 5	4 25	4 44	6
7	1 20	1 16	1 18	1 20	1 24	1 28	1 33	1 46	2 1	2 17	2 34	2 51	3 8	3 25	3 42	3 59	7
8	1 25	1 19	1 16	1 17	1 19	1 22	1 25	1 35	1 47	2 0	2 14	2 29	2 43	2 58	3 12	3 27	8
9	1 31	1 23	1 18	1 15	1 16	1 18	1 21	1 27	1 36	1 47	1 59	2 12	2 24	2 36	2 48	3 0	9
10	1 39	1 28	1 21	1 17	1 15	1 16	1 18	1 22	1 29	1 38	1 48	1 58	2 8	2 18	2 29	2 39	10
11	1 48	1 34	1 25	1 20	1 17	1 15	1 16	1 19	1 24	1 31	1 39	1 47	1 56	2 5	2 14	2 24	11
12	1 58	1 41	1 30	1 23	1 19	1 16	1 15	1 17	1 20	1 25	1 32	1 38	1 46	1 54	2 2	2 11	12
13	2 8	1 48	1 35	1 27	1 22	1 18	1 16	1 15	1 17	1 21	1 26	1 32	1 38	1 45	1 52	1 59	13
14	2 18	1 56	1 41	1 31	1 25	1 20	1 17	1 14	1 15	1 18	1 22	1 27	1 32	1 38	1 44	1 49	14
15	2 28	2 4	1 47	1 36	1 29	1 23	1 19	1 15	1 14	1 16	1 19	1 23	1 27	1 32	1 37	1 42	15
16	2 38	2 12	1 53	1 41	1 33	1 26	1 21	1 17	1 14	1 15	1 17	1 20	1 23	1 27	1 32	1 36	16
17	2 48	2 20	2 0	1 47	1 37	1 30	1 24	1 19	1 15	1 15	1 16	1 18	1 20	1 23	1 26	1 30	17
18	2 58	2 28	2 8	1 53	1 42	1 34	1 27	1 20	1 16	1 14	1 15	1 16	1 18	1 20	1 22	1 25	18
19	3 8	2 37	2 15	1 59	1 47	1 38	1 30	1 22	1 17	1 14	1 14	1 15	1 16	1 17	1 19	1 22	19
20	3 18	2 45	2 22	2 5	1 52	1 42	1 34	1 25	1 19	1 15	1 13	1 14	1 14	1 15	1 17	1 19	20
21	3 29	2 54	2 30	2 12	1 57	1 46	1 37	1 27	1 21	1 17	1 14	1 12	1 13	1 14	1 15	1 17	21
22	3 39	3 2	2 37	2 18	2 3	1 51	1 41	1 30	1 23	1 18	1 14	1 11	1 12	1 13	1 14	1 16	22
23	3 49	3 11	2 45	2 24	2 8	1 55	1 45	1 33	1 25	1 19	1 15	1 12	1 11	1 12	1 13	1 14	23
24	4 0	3 19	2 52	2 31	2 14	2 0	1 49	1 36	1 27	1 20	1 16	1 12	1 10	1 10	1 11	1 13	24
25	4 10	3 28	2 59	2 37	2 20	2 5	1 53	1 39	1 29	1 21	1 17	1 13	1 10	1 9	1 10	1 11	25
26	4 20	3 36	3 6	2 43	2 25	2 10	1 57	1 42	1 31	1 22	1 17	1 13	1 10	1 8	1 9	1 9	26
27	4 30	3 45	3 13	2 49	2 31	2 15	2 1	1 45	1 32	1 23	1 18	1 14	1 11	1 9	1 8	1 8	27
28	4 39	3 53	3 20	2 55	2 36	2 20	2 5	1 47	1 34	1 25	1 19	1 15	1 12	1 9	1 7	1 7	28
29	4 48	4 1	3 27	3 1	2 41	2 24	2 9	1 49	1 36	1 27	1 20	1 15	1 12	1 9	1 7	1 6	29
30	4 57	4 9	3 34	3 7	2 46	2 29	2 14	1 52	1 38	1 28	1 21	1 16	1 13	1 9	1 7	1 6	30
31	5 7	4 17	3 41	3 13	2 51	2 34	2 19	1 55	1 40	1 30	1 22	1 17	1 13	1 10	1 8	1 6	31
32	5 16	4 25	3 48	3 19	2 56	2 38	2 23	1 58	1 42	1 31	1 23	1 18	1 14	1 10	1 8	1 6	32
33	5 25	4 33	3 54	3 25	3 1	2 43	2 27	2 1	1 44	1 33	1 24	1 19	1 15	1 11	1 9	1 7	33
34	5 34	4 40	4 1	3 30	3 6	2 47	2 31	2 4	1 47	1 35	1 26	1 20	1 15	1 11	1 9	1 7	34
35	5 43	4 48	4 8	3 36	3 11	2 52	2 35	2 7	1 50	1 37	1 27	1 21	1 16	1 12	1 9	1 7	35
36	5 51	4 55	4 14	3 42	3 15	2 56	2 39	2 11	1 53	1 39	1 28	1 22	1 17	1 13	1 10	1 7	36
37	6 0	5 3	4 21	3 47	3 20	3 0	2 43	2 15	1 56	1 41	1 30	1 23	1 17	1 13	1 10	1 8	37
38	6 9	5 10	4 27	3 52	3 24	3 4	2 47	2 18	1 58	1 43	1 32	1 24	1 18	1 14	1 11	1 8	38
39	6 18	5 18	4 33	3 58	3 29	3 8	2 51	2 21	2 1	1 45	1 33	1 25	1 19	1 14	1 11	1 8	39
40	6 27	5 25	4 39	4 3	3 33	3 12	2 54	2 24	2 3	1 46	1 35	1 26	1 20	1 15	1 11	1 8	40
41	6 36	5 32	4 45	4 8	3 38	3 16	2 58	2 27	2 6	1 48	1 37	1 27	1 21	1 16	1 12	1 9	41
42	6 45	5 39	4 51	4 13	3 42	3 20	3 1	2 30	2 8	1 50	1 39	1 29	1 22	1 16	1 12	1 9	42
43	6 53	5 46	4 57	4 18	3 47	3 24	3 4	2 33	2 10	1 52	1 40	1 30	1 23	1 17	1 13	1 9	43
44	7 0	5 53	5 5	4 23	3 51	3 28	3 7	2 35	2 12	1 54	1 42	1 32	1 24	1 18	1 13	1 10	44
46	7 14	6 6	5 14	4 33	4 0	3 35	3 14	2 40	2 17	1 58	1 45	1 35	1 26	1 20	1 14	1 10	46
48	7 27	6 18	5 25	4 43	4 9	3 43	3 21	2 45	2 21	2 2	1 48	1 37	1 28	1 21	1 15	1 11	48
50	7 40	6 29	5 35	4 52	4 18	3 50	3 27	2 50	2 25	2 6	1 52	1 40	1 31	1 23	1 16	1 11	50
52	7 52	6 40	5 45	5 1	4 26	3 57	3 33	2 55	2 29	2 10	1 56	1 43	1 33	1 25	1 18	1 12	52
54			5 55	5 9	4 34	4 4	3 39	3 0	2 33	2 14	1 59	1 46	1 35	1 26	1 19	1 13	54
56					4 42	4 10	3 45	3 5	2 37	2 17	2 2	1 49	1 37	1 27	1 20	1 14	56
58							3 50	3 10	2 41	2 20	2 4	1 51	1 39	1 29	1 21	1 15	58
60								3 14	2 44	2 22	2 5	1 52	1 40	1 30	1 22	1 16	60
62									2 47	2 24	2 6	1 53	1 42	1 31	1 23	1 17	62
64										2 26	2 7	1 54	1 43	1 32	1 24	1 18	64
66											2 8	1 55	1 44	1 33	1 25	1 19	66
68												1 56	1 45	1 34	1 26	1 20	68
70													1 45	1 35	1 27	1 21	70
72														1 36	1 29	1 22	72
74															1 30	1 22	74
76																1 23	76
																	78
																	80
																	82
																	84
																	86
						11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Table P. Effect of Sun's Par.

Add the Numbers above the lines to Third Correction; subtract the others.

D's App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	0	1	2	4	5	6				
10	1	0	1	2	4	5				
20	3	3	1	0	2	3	4			
30	5	5	3	2	0	1	2	2		
40	7	7	5	4	2	1	0	0	1	
50	9	8	7	5	4	3	2	1	1	
60			8	7	5	4	3	2	2	
70				8	6	5	4	3		
80					7	6				

TABLE XLVIII.

Third Correction. Apparent Distance 44°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	5 3	5 22	5 41	5 59	6 36	7 10	7 40										6
7	4 15	4 31	4 47	5 2	5 33	6 1	6 29										7
8	3 40	3 53	4 6	4 20	4 46	5 11	5 35	5 58									8
9	3 12	3 24	3 35	3 47	4 10	4 31	4 51	5 10									9
10	2 50	3 0	3 10	3 20	3 39	3 58	4 17	4 34									10
11	2 33	2 42	2 52	3 0	3 17	3 33	3 48	4 3									11
12	2 19	2 27	2 36	2 44	2 59	3 13	3 26	3 39	3 51								12
13	2 6	2 13	2 21	2 29	2 43	2 56	3 9	3 20	3 29								13
14	1 55	2 2	2 9	2 16	2 29	2 41	2 53	3 2	3 10								14
15	1 47	1 53	1 59	2 5	2 17	2 28	2 38	2 47	2 54								15
16	1 40	1 45	1 50	1 56	2 7	2 17	2 26	2 34	2 41	2 47							16
17	1 34	1 38	1 43	1 48	1 58	2 7	2 15	2 22	2 29	2 35							17
18	1 29	1 33	1 37	1 42	1 51	1 59	2 6	2 12	2 18	2 24							18
19	1 25	1 28	1 32	1 35	1 44	1 52	1 59	2 4	2 9	2 14							19
20	1 22	1 25	1 28	1 31	1 38	1 46	1 52	1 57	2 1	2 6	2 11						20
21	1 19	1 22	1 25	1 27	1 33	1 40	1 46	1 51	1 55	1 59	2 2						21
22	1 17	1 19	1 22	1 24	1 29	1 35	1 40	1 45	1 49	1 53	1 55						22
23	1 15	1 17	1 19	1 21	1 25	1 30	1 35	1 40	1 44	1 47	1 49						23
24	1 14	1 15	1 16	1 18	1 22	1 26	1 30	1 35	1 39	1 42	1 44	1 46					24
25	1 12	1 13	1 14	1 16	1 19	1 22	1 26	1 30	1 34	1 37	1 39	1 40					25
26	1 10	1 11	1 12	1 14	1 16	1 19	1 22	1 26	1 30	1 32	1 34	1 35					26
27	1 9	1 10	1 11	1 12	1 14	1 16	1 19	1 23	1 26	1 28	1 30	1 31					27
28	1 8	1 9	1 10	1 11	1 12	1 14	1 17	1 20	1 22	1 24	1 26	1 27	1 28				28
29	1 7	1 8	1 8	1 9	1 10	1 12	1 15	1 17	1 19	1 21	1 22	1 23	1 25				29
30	1 6	1 7	1 7	1 8	1 9	1 10	1 12	1 14	1 16	1 18	1 19	1 20	1 22				30
31	1 6	1 6	1 6	1 7	1 8	1 8	1 10	1 12	1 14	1 15	1 17	1 18	1 19				31
32	1 5	1 6	1 6	1 6	1 7	1 7	1 8	1 10	1 12	1 13	1 14	1 15	1 16	1 17			32
33	1 5	1 5	1 5	1 5	1 6	1 6	1 7	1 8	1 9	1 10	1 11	1 12	1 13	1 14			33
34	1 5	1 4	1 4	1 4	1 5	1 5	1 6	1 6	1 7	1 8	1 9	1 10	1 11	1 12			34
35	1 5	1 4	1 4	1 4	1 4	1 4	1 5	1 5	1 5	1 6	1 7	1 8	1 9	1 10			35
36	1 5	1 4	1 3	1 3	1 3	1 3	1 4	1 4	1 4	1 5	1 5	1 6	1 7	1 8	1 9		36
37	1 6	1 4	1 3	1 2	1 2	1 2	1 3	1 3	1 3	1 4	1 4	1 5	1 5	1 6	1 7		37
38	1 6	1 4	1 2	1 1	1 1	1 1	1 2	1 2	1 2	1 3	1 3	1 4	1 4	1 4	1 5		38
39	1 6	1 4	1 2	1 1	1 0	1 0	1 1	1 1	1 1	1 2	1 2	1 3	1 3	1 3	1 4		39
40	1 6	1 4	1 2	1 1	1 0	1 0	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 1	1 2	1 3	40
41	1 7	1 5	1 3	1 1	1 0	1 0	1 0	1 0	1 0	1 0	1 0	1 0	1 0	1 0	1 0	1 1	41
42	1 7	1 5	1 3	1 1	59	59	59	59	59	59	59	59	59	59	59	59	42
43	1 7	1 5	1 3	1 1	59	59	58	58	58	58	58	58	58	58	58	58	43
44	1 7	1 5	1 3	1 1	59	58	57	57	57	57	57	57	57	57	57	57	44
46	1 7	1 5	1 3	1 1	59	57	56	56	56	56	55	55	55	55	55	55	46
48	1 8	1 6	1 4	1 2	59	57	55	55	55	54	54	54	53	53	53	53	48
50	1 8	1 6	1 4	1 2	59	57	55	54	54	53	53	53	52	52	52	52	50
52	1 9	1 6	1 4	1 2	59	56	54	53	53	52	52	51	51	51	50	51	52
54	1 10	1 7	1 4	1 2	59	56	54	53	52	51	51	50	50	49	49		54
56	1 10	1 7	1 5	1 2	59	56	54	52	51	50	50	49	49	48	47		56
58	1 11	1 8	1 5	1 3	59	56	53	51	50	49	49	48	48	47			58
60	1 11	1 8	1 5	1 3	59	56	53	51	50	49	48	47	47	46			60
62	1 12	1 9	1 6	1 3	59	56	53	51	49	48	47	47	46				62
64	1 13	1 9	1 6	1 3	59	56	53	51	49	48	47	46	45				64
66	1 14	1 10	1 7	1 4	59	56	53	51	49	48	47	46					66
68	1 15	1 11	1 7	1 4	59	56	53	51	49	47	46	45					68
70	1 16	1 11	1 7	1 4	59	55	53	51	49	47	46						70
72	1 16	1 12	1 8	1 4	59	55	52	50	48	46	45						72
74	1 16	1 12	1 8	1 4	59	55	52	50	48	46							74
76	1 17	1 12	1 8	1 5	59	55	52	49	47	46							76
78	1 17	1 12	1 8	1 5	59	55	52	49	47								78
80		1 12	1 8	1 5	59	55	52	49	47								80
82			1 8	1 5	59	55	52	49									82
84				1 5	59	55	52	49									84
86					59	55	52										86
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 48°.

D's App. Alt.	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	D's App. Alt.
	Apparent Altitude of the Sun, Star or Planet.																
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ′	′ ″	°
6	1 16	1 17	1 19	1 23	1 29	1 36	1 43	2 1	2 20	2 39	2 58	3 16	3 35	3 54	4 13	4 32	6
7	1 19	1 16	1 17	1 19	1 23	1 28	1 33	1 46	2 0	2 16	2 32	2 47	3 2	3 18	3 34	3 50	7
8	1 24	1 19	1 16	1 17	1 19	1 22	1 26	1 35	1 47	1 59	2 12	2 25	2 39	2 53	3 7	3 21	8
9	1 30	1 23	1 18	1 16	1 17	1 19	1 21	1 28	1 37	1 47	1 58	2 9	2 20	2 32	2 44	2 55	9
10	1 37	1 27	1 21	1 18	1 16	1 17	1 18	1 23	1 30	1 38	1 47	1 56	2 6	2 16	2 26	2 36	10
11	1 45	1 33	1 25	1 21	1 18	1 16	1 17	1 20	1 25	1 32	1 39	1 47	1 55	2 4	2 13	2 22	11
12	1 53	1 39	1 30	1 24	1 21	1 18	1 16	1 19	1 22	1 27	1 33	1 40	1 47	1 54	2 2	2 10	12
13	2 2	1 46	1 36	1 28	1 24	1 20	1 18	1 17	1 19	1 23	1 28	1 34	1 40	1 46	1 53	2 0	13
14	2 11	1 54	1 42	1 33	1 27	1 23	1 20	1 16	1 17	1 20	1 24	1 29	1 34	1 39	1 45	1 51	14
15	2 20	2 1	1 48	1 37	1 30	1 26	1 22	1 17	1 16	1 18	1 21	1 24	1 29	1 33	1 38	1 43	15
16	2 30	2 9	1 54	1 42	1 34	1 29	1 24	1 18	1 16	1 17	1 18	1 20	1 24	1 28	1 32	1 37	16
17	2 40	2 17	2 0	1 47	1 38	1 32	1 27	1 20	1 17	1 16	1 17	1 18	1 21	1 25	1 28	1 32	17
18	2 50	2 25	2 7	1 52	1 42	1 35	1 30	1 22	1 18	1 15	1 16	1 17	1 19	1 22	1 25	1 28	18
19	3 0	2 32	2 14	1 58	1 46	1 39	1 33	1 24	1 19	1 16	1 15	1 16	1 17	1 19	1 22	1 24	19
20	3 9	2 40	2 20	2 3	1 51	1 43	1 36	1 27	1 21	1 17	1 14	1 15	1 16	1 17	1 19	1 21	20
21	3 18	2 48	2 26	2 9	1 56	1 47	1 40	1 30	1 23	1 18	1 15	1 14	1 15	1 16	1 17	1 19	21
22	3 27	2 56	2 33	2 15	2 2	1 52	1 43	1 32	1 24	1 19	1 16	1 13	1 14	1 15	1 16	1 18	22
23	3 37	3 3	2 40	2 21	2 7	1 56	1 46	1 35	1 26	1 20	1 16	1 14	1 13	1 14	1 15	1 16	23
24	3 46	3 11	2 47	2 26	2 12	2 0	1 50	1 37	1 27	1 21	1 17	1 14	1 12	1 13	1 13	1 14	24
25	3 56	3 19	2 54	2 32	2 17	2 5	1 54	1 40	1 29	1 22	1 18	1 15	1 13	1 12	1 12	1 13	25
26	4 5	3 27	3 1	2 38	2 22	2 9	1 58	1 42	1 31	1 24	1 19	1 16	1 13	1 11	1 11	1 12	26
27	4 15	3 34	3 8	2 44	2 27	2 14	2 2	1 44	1 33	1 25	1 20	1 16	1 13	1 11	1 10	1 11	27
28	4 24	3 42	3 15	2 50	2 32	2 18	2 6	1 47	1 35	1 27	1 21	1 17	1 14	1 12	1 10	1 10	28
29	4 33	3 50	3 21	2 56	2 37	2 23	2 10	1 50	1 37	1 28	1 22	1 18	1 15	1 12	1 10	1 9	29
30	4 42	3 58	3 28	3 2	2 42	2 27	2 13	1 53	1 40	1 30	1 23	1 19	1 15	1 12	1 10	1 9	30
31	4 51	4 6	3 35	3 8	2 47	2 31	2 17	1 57	1 42	1 32	1 25	1 20	1 16	1 13	1 11	1 9	31
32	5 0	4 13	3 42	3 14	2 52	2 35	2 20	2 0	1 44	1 33	1 26	1 21	1 16	1 13	1 11	1 9	32
33	5 9	4 21	3 49	3 20	2 57	2 39	2 23	2 3	1 46	1 35	1 27	1 22	1 17	1 14	1 12	1 10	33
34	5 18	4 28	3 55	3 25	3 2	2 44	2 27	2 6	1 49	1 37	1 28	1 23	1 18	1 14	1 12	1 10	34
35	5 27	4 36	4 1	3 31	3 7	2 48	2 31	2 9	1 52	1 39	1 30	1 24	1 19	1 15	1 12	1 10	35
36	5 35	4 43	4 8	3 37	3 12	2 52	2 35	2 12	1 54	1 41	1 31	1 25	1 19	1 15	1 12	1 10	36
37	5 44	4 50	4 14	3 42	3 17	2 57	2 39	2 -6	1 56	1 43	1 33	1 26	1 20	1 16	1 13	1 11	37
38	5 52	4 57	4 20	3 47	3 22	3 1	2 43	2 19	1 59	1 45	1 34	1 27	1 21	1 17	1 14	1 11	38
39	6 0	5 4	4 26	3 53	3 26	3 5	2 47	2 22	2 2	1 47	1 35	1 28	1 22	1 17	1 14	1 11	39
40	6 8	5 11	4 32	3 58	3 30	3 10	2 51	2 25	2 5	1 49	1 37	1 29	1 23	1 18	1 15	1 12	40
41	6 16	5 18	4 38	4 3	3 35	3 14	2 55	2 28	2 7	1 51	1 39	1 31	1 24	1 19	1 16	1 13	41
42	6 24	5 24	4 44	4 8	3 40	3 18	2 58	2 31	2 10	1 53	1 41	1 33	1 26	1 20	1 16	1 13	42
43	6 32	5 31	4 50	4 13	3 44	3 22	3 2	2 33	2 12	1 55	1 43	1 34	1 27	1 21	1 17	1 14	43
44	6 39	5 37	4 55	4 18	3 48	3 26	3 5	2 36	2 14	1 57	1 45	1 36	1 28	1 22	1 18	1 15	44
46	6 53	5 49	5 5	4 28	3 56	3 34	3 12	2 41	2 18	2 1	1 48	1 38	1 30	1 23	1 18	1 15	46
48	7 7	6 1	5 15	4 37	4 4	3 41	3 18	2 46	2 22	2 5	1 51	1 40	1 31	1 24	1 19	1 16	48
50	7 21	6 13	5 25	4 46	4 12	3 47	3 24	2 51	2 26	2 8	1 53	1 42	1 33	1 25	1 20	1 16	50
52	7 34	6 24	5 34	4 54	4 20	3 53	3 30	2 56	2 30	2 12	1 56	1 44	1 35	1 27	1 22	1 17	52
54	7 47	6 35	5 43	5 1	4 27	3 59	3 36	3 1	2 34	2 15	1 59	1 46	1 37	1 29	1 23	1 19	54
56	8 0	6 46	5 51	5 8	4 34	4 5	3 41	3 6	2 38	2 18	2 2	1 49	1 39	1 31	1 25	1 20	56
58			5 59	5 15	4 40	4 11	3 46	3 10	2 42	2 21	2 4	1 51	1 41	1 32	1 26	1 21	58
					4 46	4 16	3 50	3 13	2 45	2 23	2 6	1 53	1 42	1 33	1 27	1 21	60
							3 54	3 15	2 47	2 25	2 8	1 54	1 43	1 34	1 28	1 22	62
								3 17	2 49	2 27	2 10	1 56	1 45	1 35	1 28	1 22	64
									2 51	2 29	2 11	1 57	1 46	1 36	1 29	1 23	66
										2 31	2 12	1 58	1 47	1 37	1 30	1 24	68
											2 13	1 59	1 48	1 38	1 30	1 24	70
												2 0	1 49	1 39	1 31	1 24	72
													1 50	1 40	1 32	1 25	74
														1 41	1 33	1 25	76
															1 33	1 26	78
																1 26	80
																	82
																	84
																	86
					10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Table P. Effect of Sun's Par.

Add the Numbers above the lines to Third Correction ; subtract the others.

D's App. Alt.	5	10	20	30	40	50	60	70	80	90
	Sun's Apparent Altitude.									
	″	″	″	″	″	″	″	″	″	″
5	0	1	2	3	4	5				
10	1	1	1	2	3	4	5			
20	3	3	1	0	1	2	3	3		
30	5	5	3	2	1	0	1	2		
40	7	6	5	4	3	2	1	0	0	0
50	9	8	6	5	4	3	2	2	1	
60		9	8	6	5	4	3	3		
70			9	7	6	5	4			
80				8	7	6				
90					7					

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 48°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	4 51	5 10	5 28	5 46	6 18	6 49	7 19	7 47									6
7	4 6	4 21	4 36	4 51	5 19	5 45	6 11	6 35									7
8	3 34	3 48	4 1	4 14	4 38	5 1	5 22	5 42	6 1								8
9	3 7	3 19	3 30	3 41	4 3	4 24	4 43	5 0	5 17								9
10	2 47	2 57	3 7	3 17	3 36	3 54	4 11	4 26	4 40								10
11	2 31	2 40	2 49	2 57	3 14	3 30	3 44	3 57	4 10								11
12	2 17	2 25	2 33	2 40	2 55	3 9	3 22	3 34	3 45	3 55							12
13	2 6	2 13	2 20	2 27	2 40	2 52	3 4	3 15	3 25	3 32							13
14	1 57	2 4	2 10	2 16	2 27	2 38	2 49	2 59	3 8	3 15							14
15	1 49	1 55	2 1	2 6	2 16	2 26	2 35	2 44	2 53	3 0							15
16	1 42	1 47	1 52	1 57	2 7	2 15	2 23	2 32	2 40	2 46	2 52						16
17	1 36	1 41	1 45	1 50	1 59	2 6	2 14	2 22	2 29	2 34	2 40						17
18	1 31	1 35	1 39	1 43	1 51	1 59	2 6	2 13	2 19	2 24	2 29						18
19	1 27	1 31	1 34	1 38	1 45	1 52	1 58	2 4	2 10	2 15	2 19						19
20	1 24	1 27	1 30	1 33	1 39	1 45	1 51	1 57	2 2	2 7	2 11	2 15					20
21	1 22	1 24	1 27	1 29	1 34	1 40	1 45	1 51	1 56	2 0	2 4	2 7					21
22	1 20	1 22	1 24	1 26	1 30	1 35	1 40	1 45	1 50	1 54	1 57	1 59					22
23	1 18	1 19	1 21	1 23	1 27	1 31	1 36	1 40	1 45	1 49	1 51	1 53					23
24	1 16	1 17	1 19	1 21	1 25	1 28	1 32	1 36	1 40	1 44	1 46	1 48	1 50				24
25	1 14	1 15	1 16	1 18	1 22	1 25	1 29	1 32	1 36	1 39	1 41	1 43	1 45				25
26	1 12	1 13	1 14	1 16	1 19	1 23	1 26	1 29	1 32	1 34	1 36	1 38	1 40				26
27	1 11	1 12	1 13	1 14	1 17	1 20	1 23	1 26	1 28	1 30	1 32	1 34	1 36				27
28	1 10	1 11	1 12	1 13	1 15	1 18	1 20	1 23	1 25	1 27	1 28	1 30	1 32	1 34			28
29	1 9	1 10	1 11	1 12	1 14	1 16	1 18	1 20	1 22	1 24	1 25	1 27	1 28	1 30			29
30	1 9	1 10	1 10	1 11	1 12	1 14	1 16	1 18	1 19	1 21	1 22	1 24	1 25	1 26			30
31	1 9	1 9	1 9	1 10	1 11	1 12	1 14	1 16	1 17	1 19	1 20	1 21	1 22	1 23			31
32	1 8	1 8	1 8	1 9	1 10	1 11	1 13	1 14	1 15	1 17	1 18	1 19	1 19	1 20	1 21		32
33	1 8	1 7	1 7	1 8	1 9	1 10	1 11	1 12	1 13	1 15	1 16	1 17	1 17	1 17	1 18		33
34	1 8	1 6	1 6	1 7	1 8	1 9	1 10	1 11	1 12	1 13	1 14	1 14	1 15	1 15	1 16		34
35	1 8	1 6	1 5	1 6	1 7	1 8	1 9	1 9	1 10	1 11	1 12	1 12	1 13	1 13	1 14		35
36	1 8	1 6	1 5	1 5	1 5	1 6	1 7	1 7	1 8	1 9	1 10	1 10	1 11	1 11	1 12	1 13	36
37	1 9	1 7	1 5	1 4	1 4	1 5	1 6	1 6	1 7	1 7	1 8	1 8	1 9	1 9	1 10	1 11	37
38	1 9	1 7	1 5	1 3	1 3	1 4	1 5	1 5	1 6	1 6	1 7	1 7	1 8	1 8	1 8	1 9	38
39	1 9	1 7	1 5	1 3	1 3	1 3	1 4	1 4	1 5	1 5	1 6	1 6	1 6	1 7	1 7	1 7	39
40	1 9	1 7	1 5	1 3	1 2	1 2	1 3	1 3	1 4	1 4	1 5	1 5	1 5	1 6	1 6	1 6	40
41	1 10	1 8	1 5	1 3	1 1	1 1	1 2	1 2	1 3	1 3	1 4	1 4	1 4	1 5	1 5	1 5	41
42	1 10	1 8	1 5	1 3	1 1	1 1	1 1	1 2	1 2	1 2	1 3	1 3	1 3	1 4	1 4	1 4	42
43	1 11	1 8	1 6	1 4	1 1	1 0	1 0	1 1	1 1	1 1	1 2	1 2	1 2	1 3	1 3	1 3	43
44	1 12	1 9	1 6	1 4	1 1	1 0	1 0	1 0	1 0	1 0	1 1	1 1	1 1	1 1	1 1	1 1	44
46	1 12	1 9	1 6	1 4	1 1	59	59	59	59	59	59	59	59	59	59	59	46
48	1 13	1 10	1 7	1 4	1 1	59	58	58	58	58	57	57	57	57	57	57	48
50	1 13	1 10	1 7	1 5	1 1	59	57	57	57	57	56	56	56	56	56		50
52	1 14	1 11	1 8	1 5	1 1	59	57	56	56	56	55	55	54	54	54		52
54	1 15	1 11	1 8	1 6	1 2	59	57	56	55	55	54	54	53	53			54
56	1 15	1 11	1 8	1 6	1 2	59	57	55	54	54	53	53	52	52			56
58	1 16	1 12	1 9	1 6	1 2	59	57	55	54	53	52	52	51				58
60	1 16	1 12	1 9	1 6	1 2	59	57	55	53	52	52	51	50				60
62	1 17	1 13	1 10	1 7	1 2	59	57	55	53	52	51	51					62
64	1 17	1 13	1 10	1 7	1 2	59	57	55	53	52	51	50					64
66	1 18	1 14	1 10	1 7	1 3	59	57	54	52	51	50						66
68	1 18	1 14	1 10	1 7	1 3	59	56	54	52	51	50						68
70	1 19	1 15	1 11	1 8	1 3	59	56	54	52	51							70
72	1 19	1 15	1 11	1 8	1 3	59	56	54	52	50							72
74	1 20	1 15	1 11	1 8	1 3	59	56	53	51								74
76	1 20	1 16	1 12	1 8	1 3	59	56	53	51								76
78	1 21	1 16	1 12	1 9	1 4	59	56	53									78
80	1 21	1 16	1 12	1 9	1 4	59	56	53									80
82	1 21	1 16	1 12	1 9	1 4	59	56										82
84		1 16	1 12	1 9	1 4	59	56										84
86			1 12	1 9	1 4	59											86
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 52°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	′ ″	′ ″	′ ″	°
6	1 18	1 19	1 21	1 24	1 30	1 37	1 44	2 0	2 17	2 34	2 51	3 10	3 28	3 47	4 6	4 24	6
7	1 21	1 18	1 19	1 21	1 24	1 29	1 34	1 46	2 0	2 14	2 28	2 42	2 57	3 12	3 27	3 43	7
8	1 25	1 21	1 18	1 19	1 21	1 24	1 27	1 36	1 47	1 58	2 11	2 23	2 36	2 50	3 3	3 16	8
9	1 30	1 24	1 20	1 18	1 19	1 21	1 23	1 29	1 37	1 47	1 57	2 8	2 19	2 31	2 42	2 53	9
10	1 37	1 28	1 23	1 20	1 18	1 19	1 21	1 25	1 30	1 38	1 46	1 56	2 6	2 16	2 26	2 36	10
11	1 45	1 34	1 28	1 23	1 20	1 18	1 19	1 22	1 26	1 32	1 39	1 47	1 56	2 4	2 13	2 22	11
12	1 54	1 41	1 33	1 27	1 22	1 20	1 18	1 20	1 23	1 27	1 33	1 40	1 47	1 54	2 2	2 10	12
13	2 2	1 48	1 38	1 31	1 25	1 22	1 19	1 19	1 21	1 24	1 29	1 35	1 41	1 47	1 54	2 1	13
14	2 11	1 55	1 44	1 35	1 28	1 24	1 21	1 18	1 19	1 22	1 26	1 30	1 35	1 41	1 47	1 52	14
15	2 19	2 2	1 50	1 39	1 32	1 27	1 23	1 19	1 18	1 20	1 23	1 26	1 30	1 35	1 40	1 44	15
16	2 28	2 9	1 55	1 44	1 35	1 30	1 25	1 20	1 17	1 18	1 20	1 23	1 26	1 30	1 34	1 38	16
17	2 37	2 16	2 0	1 48	1 39	1 33	1 27	1 21	1 18	1 17	1 18	1 20	1 23	1 26	1 30	1 33	17
18	2 46	2 23	2 6	1 53	1 43	1 36	1 30	1 23	1 19	1 16	1 17	1 18	1 20	1 23	1 26	1 29	18
19	2 56	2 30	2 12	1 59	1 48	1 40	1 33	1 25	1 20	1 17	1 16	1 17	1 18	1 20	1 23	1 26	19
20	3 5	2 37	2 18	2 4	1 52	1 44	1 37	1 27	1 22	1 18	1 15	1 16	1 17	1 18	1 20	1 23	20
21	3 14	2 44	2 24	2 9	1 57	1 48	1 40	1 29	1 23	1 19	1 16	1 16	1 16	1 17	1 18	1 20	21
22	3 23	2 52	2 31	2 15	2 1	1 52	1 44	1 32	1 25	1 20	1 16	1 15	1 15	1 16	1 17	1 18	22
23	3 32	2 59	2 38	2 20	2 6	1 56	1 47	1 34	1 26	1 21	1 17	1 15	1 14	1 15	1 16	1 17	23
24	3 41	3 7	2 44	2 26	2 11	2 0	1 51	1 37	1 28	1 22	1 18	1 15	1 14	1 14	1 15	1 16	24
25	3 50	3 14	2 51	2 31	2 16	2 4	1 54	1 40	1 30	1 23	1 19	1 16	1 14	1 13	1 14	1 15	25
26	3 59	3 22	2 58	2 37	2 21	2 8	1 58	1 42	1 32	1 25	1 20	1 16	1 14	1 13	1 13	1 14	26
27	4 8	3 30	3 5	2 42	2 26	2 12	2 2	1 45	1 33	1 26	1 21	1 17	1 15	1 14	1 13	1 13	27
28	4 17	3 38	3 12	2 48	2 31	2 16	2 6	1 48	1 35	1 28	1 22	1 18	1 15	1 14	1 13	1 13	28
29	4 26	3 45	3 19	2 53	2 36	2 21	2 10	1 51	1 37	1 29	1 23	1 19	1 16	1 14	1 13	1 12	29
30	4 34	3 53	3 25	2 59	2 41	2 25	2 13	1 54	1 39	1 31	1 24	1 19	1 16	1 14	1 13	1 12	30
31	4 43	4 0	3 32	3 5	2 45	2 29	2 17	1 57	1 41	1 32	1 25	1 20	1 17	1 15	1 13	1 12	31
32	4 52	4 8	3 38	3 10	2 50	2 34	2 20	1 59	1 43	1 34	1 27	1 21	1 17	1 15	1 13	1 12	32
33	5 0	4 15	3 44	3 16	2 55	2 38	2 24	2 2	1 45	1 36	1 29	1 23	1 18	1 15	1 13	1 12	33
34	5 9	4 22	3 50	3 21	2 59	2 42	2 27	2 5	1 48	1 38	1 30	1 24	1 19	1 16	1 14	1 12	34
35	5 17	4 29	3 56	3 27	3 4	2 46	2 31	2 7	1 51	1 40	1 32	1 25	1 20	1 17	1 14	1 12	35
36	5 26	4 36	4 2	3 32	3 9	2 50	2 34	2 10	1 53	1 42	1 33	1 26	1 21	1 17	1 14	1 12	36
37	5 34	4 42	4 8	3 37	3 14	2 54	2 38	2 13	1 56	1 44	1 34	1 27	1 22	1 18	1 15	1 13	37
38	5 42	4 49	4 13	3 42	3 18	2 58	2 42	2 16	1 58	1 46	1 36	1 28	1 22	1 18	1 15	1 13	38
39	5 50	4 56	4 19	3 47	3 23	3 2	2 46	2 19	2 1	1 48	1 38	1 30	1 23	1 18	1 15	1 13	39
40	5 58	5 3	4 24	3 52	3 27	3 6	2 49	2 22	2 3	1 50	1 39	1 31	1 25	1 19	1 16	1 14	40
41	6 6	5 9	4 30	3 57	3 32	3 10	2 53	2 25	2 6	1 52	1 41	1 32	1 26	1 20	1 16	1 14	41
42	6 14	5 15	4 35	4 2	3 36	3 14	2 56	2 28	2 8	1 54	1 42	1 34	1 27	1 21	1 17	1 15	42
43	6 21	5 21	4 41	4 7	3 40	3 18	3 0	2 31	2 11	1 56	1 44	1 35	1 28	1 22	1 18	1 15	43
44	6 28	5 27	4 46	4 12	3 44	3 22	3 3	2 34	2 13	1 58	1 45	1 37	1 29	1 23	1 19	1 16	44
46	6 42	5 39	4 56	4 21	3 52	3 29	3 10	2 39	2 18	2 1	1 48	1 39	1 31	1 24	1 20	1 17	46
48	6 55	5 51	5 6	4 30	3 59	3 36	3 16	2 44	2 22	2 5	1 51	1 41	1 33	1 26	1 21	1 18	48
50	7 8	6 2	5 16	4 38	4 7	3 43	3 23	2 49	2 26	2 8	1 54	1 43	1 35	1 27	1 22	1 19	50
52	7 21	6 13	5 25	4 46	4 15	3 50	3 29	2 54	2 30	2 11	1 57	1 45	1 36	1 29	1 24	1 20	52
54	7 33	6 23	5 34	4 53	4 22	3 56	3 35	2 59	2 34	2 14	2 0	1 48	1 38	1 31	1 25	1 21	54
56	7 44	6 33	5 43	4 59	4 29	4 2	3 40	3 4	2 38	2 17	2 2	1 50	1 40	1 32	1 26	1 22	56
58	7 53	6 42	5 50	5 6	4 35	4 7	3 45	3 8	2 42	2 20	2 5	1 53	1 42	1 33	1 27	1 23	58
60	8 2	6 49	5 56	5 12	4 40	4 12	3 50	3 12	2 46	2 23	2 7	1 55	1 44	1 35	1 29	1 24	60
62			6 2	5 17	4 45	4 16	3 54	3 15	2 49	2 26	2 9	1 57	1 46	1 36	1 30	1 25	62
64					4 50	4 20	3 58	3 18	2 51	2 28	2 11	1 59	1 48	1 37	1 31	1 26	64
66							4 1	3 20	2 53	2 30	2 13	2 0	1 49	1 39	1 32	1 26	66
68								3 22	2 54	2 32	2 15	2 1	1 50	1 40	1 33	1 27	68
70									2 55	2 33	2 16	2 2	1 51	1 41	1 34	1 28	70
72										2 34	2 17	2 3	1 52	1 42	1 34	1 28	72
74											2 18	2 4	1 53	1 43	1 35	1 29	74
76												2 5	1 54	1 44	1 36	1 29	76
78													1 55	1 44	1 36	1 30	78
80														1 45	1 37	1 30	80
82															1 38	1 30	82
84																1 3[illegible]	84
86																	86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 52°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	4 43	5 1	5 18	5 34	6 6	6 36	7 4	7 29	7 53								6
7	3 59	4 14	4 29	4 43	5 9	5 34	5 58	6 20	6 42								7
8	3 30	3 43	3 55	4 8	4 30	4 52	5 13	5 32	5 50	6 6							8
9	3 4	3 15	3 26	3 37	3 58	4 17	4 36	4 51	5 5	5 18							9
10	2 45	2 54	3 4	3 14	3 32	3 48	4 4	4 20	4 33	4 45							10
11	2 30	2 38	2 47	2 55	3 11	3 26	3 40	3 54	4 6	4 16							11
12	2 17	2 25	2 32	2 40	2 54	3 7	3 20	3 32	3 43	3 52	4 1						12
13	2 7	2 13	2 20	2 26	2 39	2 51	3 3	3 14	3 24	3 32	3 38						13
14	1 58	2 3	2 9	2 14	2 26	2 37	2 48	2 58	3 7	3 14	3 20						14
15	1 49	1 54	1 59	2 4	2 15	2 26	2 35	2 44	2 52	2 59	3 5						15
16	1 42	1 47	1 51	1 56	2 7	2 16	2 24	2 32	2 40	2 46	2 52	2 57					16
17	1 37	1 41	1 45	1 50	2 0	2 8	2 15	2 22	2 29	2 35	2 40	2 44					17
18	1 32	1 36	1 40	1 45	1 53	2 0	2 7	2 13	2 19	2 25	2 30	2 33					18
19	1 29	1 32	1 36	1 40	1 47	1 53	2 0	2 6	2 11	2 16	2 21	2 24					19
20	1 26	1 29	1 32	1 35	1 41	1 47	1 53	1 59	2 4	2 9	2 13	2 16	2 19				20
21	1 23	1 26	1 28	1 31	1 37	1 42	1 47	1 53	1 58	2 2	2 6	2 9	2 11				21
22	1 21	1 23	1 25	1 28	1 33	1 37	1 42	1 47	1 52	1 56	1 59	2 2	2 4				22
23	1 19	1 21	1 23	1 25	1 29	1 33	1 38	1 42	1 47	1 51	1 54	1 56	1 58				23
24	1 17	1 19	1 21	1 23	1 26	1 30	1 34	1 38	1 42	1 46	1 49	1 51	1 53	1 55			24
25	1 16	1 17	1 19	1 20	1 23	1 27	1 30	1 34	1 37	1 41	1 44	1 46	1 48	1 49			25
26	1 15	1 16	1 17	1 18	1 21	1 24	1 27	1 30	1 33	1 36	1 39	1 41	1 43	1 44			26
27	1 14	1 15	1 16	1 17	1 19	1 22	1 24	1 27	1 30	1 32	1 35	1 37	1 39	1 40			27
28	1 13	1 14	1 15	1 16	1 17	1 20	1 22	1 24	1 27	1 29	1 31	1 33	1 35	1 36	1 37		28
29	1 12	1 13	1 14	1 15	1 16	1 18	1 20	1 22	1 24	1 26	1 28	1 30	1 31	1 32	1 33		29
30	1 12	1 12	1 13	1 13	1 14	1 16	1 18	1 20	1 22	1 24	1 25	1 27	1 28	1 29	1 30		30
31	1 11	1 11	1 12	1 12	1 13	1 15	1 16	1 18	1 20	1 22	1 23	1 24	1 25	1 26	1 27		31
32	1 11	1 11	1 11	1 11	1 12	1 14	1 15	1 16	1 18	1 20	1 21	1 22	1 23	1 23	1 24	1 25	32
33	1 11	1 10	1 10	1 10	1 11	1 13	1 14	1 15	1 17	1 18	1 19	1 20	1 21	1 21	1 22	1 22	33
34	1 11	1 10	1 10	1 10	1 11	1 12	1 13	1 14	1 16	1 17	1 17	1 18	1 19	1 19	1 20	1 20	34
35	1 11	1 10	1 10	1 10	1 10	1 11	1 12	1 13	1 14	1 15	1 15	1 16	1 17	1 17	1 18	1 18	35
36	1 11	1 10	1 9	1 9	1 9	1 10	1 11	1 11	1 12	1 13	1 13	1 14	1 15	1 15	1 16	1 16	36
37	1 11	1 10	1 9	1 9	1 9	1 9	1 10	1 10	1 11	1 11	1 12	1 12	1 13	1 13	1 14	1 14	37
38	1 11	1 10	1 9	1 8	1 8	1 9	1 9	1 9	1 10	1 10	1 11	1 11	1 11	1 11	1 12	1 12	38
39	1 11	1 10	1 9	1 8	1 8	1 8	1 8	1 8	1 9	1 9	1 10	1 10	1 10	1 10	1 10	1 10	39
40	1 12	1 10	1 9	1 8	1 7	1 7	1 7	1 7	1 8	1 8	1 9	1 9	1 9	1 9	1 9	1 9	40
41	1 12	1 11	1 9	1 8	1 7	1 7	: 7	1 7	1 7	1 7	1 8	1 8	1 8	1 8	1 8	1 8	41
42	1 13	1 11	1 9	1 8	1 6	1 6	1 6	1 6	1 6	1 6	1 7	1 7	1 7	1 7	1 7	1 7	42
43	1 13	1 11	1 9	1 8	1 6	1 6	1 6	1 6	1 6	1 6	1 6	1 6	1 6	1 6	1 6	1 6	43
44	1 14	1 11	1 9	1 8	1 6	1 5	1 5	1 5	1 5	1 5	1 5	1 5	1 5	1 5	1 5	1 5	44
46	1 14	1 12	1 10	1 9	1 6	1 4	1 4	1 4	1 4	1 4	1 4	1 3	1 3	1 3	1 3		46
48	1 15	1 13	1 11	1 9	1 6	1 4	1 3	1 3	1 3	1 2	1 2	1 1	1 1	1 1	1 1		48
50	1 16	1 14	1 11	1 9	1 6	1 4	1 2	1 2	1 2	1 1	1 1	1 0	1 0	1 0			50
52	1 17	1 15	1 12	1 9	1 6	1 4	1 2	1 1	1 1	1 0	1 0	59	58	58			52
54	1 18	1 15	1 12	1 9	1 6	1 4	1 2	1 1	1 0	59	59	58	57				54
56	1 18	1 15	1 12	1 10	1 6	1 4	1 2	1 0	59	58	58	57	56				56
58	1 19	1 16	1 13	1 10	1 6	1 4	1 2	1 0	59	58	57	56					58
60	1 20	1 16	1 13	1 10	1 7	1 4	1 2	1 0	58	57	56	55					60
62	1 21	1 17	1 13	1 10	1 7	1 4	1 1	59	58	56	55						62
64	1 22	1 18	1 14	1 11	1 7	1 4	1 1	59	57	56	54						64
66	1 22	1 18	1 14	1 11	1 7	1 4	1 1	59	57	55							66
68	1 22	1 18	1 14	1 11	1 7	1 3	1 0	58	56	54							68
70	1 23	1 18	1 14	1 11	1 7	1 3	1 0	58	56								70
72	1 23	1 19	1 15	1 11	1 7	1 3	1 0	57	55								72
74	1 24	1 19	1 15	1 11	1 7	1 3	1 0	57									74
76	1 24	1 19	1 15	1 12	1 7	1 3	1 0	56									76
78	1 24	1 19	1 15	1 12	1 7	1 3	1 0										
80	1 24	1 19	1 15	1 12	1 7	1 3	1 0										
82	1 25	1 20	1 16	1 12	1 7	1 3											
84	1 25	1 20	1 16	1 12	1 7	1 3											
86	1 25	1 21	1 16	1 12	1 7												
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°					

Table P. Effect of Sun's Par

Add the Numbers above the lines to Third Correction; subtract the others.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	0	1	2	3	4	4				
10	1	1	1	2	3	3	4			
20	3	3	1	0	1	2	2	3		
30	5	4	3	2	1	0	0	1		
40	7	6	5	4	3	2	1	1	0	0
50	8	8	6	5	4	3	3	2	2	
60		9	7	6	5	4	4	3		
70			8	7	6	5	5			
80				8	7	6				
90					7					

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 56°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 20	1 22	1 25	1 29	1 35	1 41	1 48	2 2	2 18	2 35	2 52	3 10	3 27	3 45	4 3	4 20	6
7	1 23	1 20	1 22	1 24	1 27	1 32	1 37	1 48	2 1	2 15	2 29	2 43	2 58	3 12	3 27	3 42	7
8	1 28	1 23	1 20	1 21	1 23	1 26	1 29	1 38	1 48	2 0	2 12	2 23	2 35	2 48	3 1	3 14	8
9	1 34	1 27	1 22	1 20	1 21	1 23	1 25	1 31	1 39	1 48	1 58	2 8	2 18	2 29	2 40	2 50	9
10	1 40	1 31	1 25	1 22	1 20	1 21	1 22	1 26	1 32	1 39	1 48	1 56	2 5	2 15	2 24	2 33	10
11	1 47	1 36	1 29	1 25	1 22	1 20	1 21	1 23	1 27	1 33	1 40	1 47	1 55	2 4	2 12	2 20	11
12	1 54	1 42	1 33	1 28	1 24	1 21	1 20	1 21	1 24	1 28	1 34	1 40	1 47	1 55	2 2	2 9	12
13	2 2	1 48	1 38	1 31	1 26	1 23	1 21	1 20	1 22	1 25	1 30	1 35	1 41	1 47	1 54	2 0	13
14	2 10	1 54	1 43	1 35	1 29	1 25	1 22	1 19	1 20	1 23	1 27	1 31	1 36	1 41	1 47	1 52	14
15	2 18	2 1	1 48	1 39	1 33	1 28	1 24	1 21	1 19	1 21	1 24	1 27	1 32	1 36	1 41	1 46	15
16	2 27	2 8	1 53	1 43	1 36	1 31	1 26	1 22	1 19	1 19	1 21	1 24	1 28	1 32	1 36	1 40	16
17	2 35	2 15	1 59	1 47	1 40	1 34	1 29	1 23	1 20	1 18	1 19	1 22	1 25	1 28	1 32	1 35	17
18	2 44	2 22	2 4	1 52	1 43	1 37	1 31	1 25	1 20	1 17	1 18	1 20	1 22	1 25	1 28	1 31	18
19	2 53	2 29	2 10	1 57	1 47	1 40	1 34	1 26	1 21	1 18	1 17	1 19	1 20	1 23	1 25	1 28	19
20	3 2	2 36	2 16	2 2	1 51	1 44	1 37	1 28	1 22	1 19	1 17	1 18	1 19	1 21	1 23	1 25	20
21	3 11	2 44	2 22	2 8	1 55	1 47	1 40	1 30	1 24	1 20	1 18	1 17	1 18	1 19	1 21	1 23	21
22	3 20	2 51	2 29	2 13	2 0	1 51	1 43	1 32	1 25	1 21	1 18	1 16	1 17	1 18	1 19	1 21	22
23	3 29	2 58	2 35	2 18	2 5	1 55	1 46	1 35	1 27	1 22	1 19	1 17	1 16	1 17	1 18	1 19	23
24	3 38	3 5	2 42	2 23	2 9	1 59	1 50	1 37	1 29	1 24	1 20	1 17	1 16	1 16	1 17	1 18	24
25	3 47	3 13	2 49	2 29	2 14	2 3	1 53	1 39	1 31	1 25	1 21	1 18	1 16	1 16	1 16	1 17	25
26	3 55	3 20	2 55	2 34	2 19	2 7	1 57	1 42	1 33	1 27	1 22	1 19	1 17	1 16	1 16	1 16	26
27	4 4	3 27	3 1	2 39	2 24	2 12	2 1	1 45	1 35	1 28	1 23	1 19	1 17	1 16	1 16	1 16	27
28	4 12	3 34	3 8	2 45	2 29	2 16	2 5	1 48	1 37	1 30	1 24	1 20	1 18	1 16	1 15	1 16	28
29	4 21	3 41	3 14	2 50	2 33	2 20	2 8	1 51	1 39	1 31	1 25	1 21	1 18	1 16	1 15	1 15	29
30	4 29	3 48	3 20	2 55	2 38	2 24	2 12	1 54	1 41	1 33	1 26	1 21	1 18	1 16	1 15	1 15	30
31	4 38	3 55	3 26	3 0	2 43	2 28	2 16	1 57	1 44	1 34	1 28	1 22	1 18	1 16	1 16	1 15	31
32	4 46	4 2	3 32	3 6	2 48	2 32	2 19	2 0	1 46	1 36	1 29	1 23	1 19	1 17	1 16	1 15	32
33	4 54	4 9	3 39	3 11	2 53	2 36	2 23	2 3	1 49	1 38	1 31	1 25	1 20	1 17	1 16	1 15	33
34	5 2	4 16	3 45	3 16	2 57	2 40	2 26	2 6	1 51	1 40	1 32	1 26	1 21	1 18	1 16	1 15	34
35	5 10	4 23	3 51	3 22	3 2	2 44	2 30	2 9	1 53	1 42	1 34	1 27	1 22	1 18	1 16	1 15	35
36	5 18	4 30	3 57	3 27	3 6	2 48	2 33	2 12	1 55	1 44	1 35	1 28	1 23	1 19	1 17	1 16	36
37	5 26	4 37	4 3	3 32	3 10	2 52	2 37	2 15	1 58	1 46	1 37	1 29	1 24	1 20	1 18	1 16	37
38	5 33	4 43	4 8	3 37	3 14	2 56	2 41	2 17	2 0	1 48	1 38	1 30	1 25	1 21	1 18	1 16	38
39	5 41	4 50	4 14	3 42	3 19	3 0	2 45	2 20	2 2	1 50	1 39	1 31	1 25	1 21	1 18	1 16	39
40	5 48	4 56	4 19	3 47	3 23	3 4	2 48	2 23	2 4	1 51	1 40	1 32	1 26	1 22	1 19	1 16	40
41	5 55	5 2	4 25	3 52	3 28	3 8	2 51	2 25	2 6	1 53	1 42	1 33	1 27	1 23	1 20	1 17	41
42	6 2	5 8	4 30	3 57	3 32	3 11	2 54	2 28	2 9	1 55	1 43	1 34	1 28	1 24	1 20	1 17	42
43	6 9	5 14	4 35	4 2	3 36	3 15	2 58	2 31	2 12	1 57	1 44	1 35	1 29	1 25	1 21	1 17	43
44	6 16	5 20	4 40	4 7	3 40	3 19	3 1	2 34	2 14	1 59	1 46	1 37	1 31	1 26	1 22	1 18	44
46	6 29	5 32	4 50	4 16	3 48	3 26	3 8	2 40	2 18	2 2	1 49	1 40	1 33	1 28	1 23	1 19	46
48	6 42	5 43	4 59	4 24	3 56	3 33	3 14	2 45	2 22	2 6	1 52	1 43	1 36	1 30	1 25	1 20	48
50	6 54	5 54	5 8	4 32	4 3	3 40	3 19	2 50	2 26	2 9	1 55	1 45	1 38	1 32	1 26	1 21	50
52	7 6	6 4	5 17	4 39	4 10	3 46	3 24	2 55	2 30	2 12	1 58	1 48	1 40	1 33	1 27	1 22	52
54	7 18	6 14	5 25	4 46	4 16	3 52	3 29	2 59	2 34	2 15	2 0	1 50	1 42	1 35	1 29	1 24	54
56	7 29	6 24	5 33	4 53	4 22	3 57	3 34	3 3	2 37	2 19	2 3	1 52	1 43	1 36	1 30	1 25	56
58	7 40	6 33	5 41	5 0	4 28	4 2	3 39	3 7	2 41	2 22	2 6	1 54	1 45	1 37	1 31	1 26	58
60	7 50	6 41	5 48	5 7	4 34	4 7	3 43	3 11	2 44	2 25	2 8	1 56	1 47	1 39	1 32	1 27	60
62	7 58	6 48	5 55	5 13	4 40	4 12	3 48	3 15	2 47	2 28	2 11	1 58	1 48	1 40	1 33	1 28	62
64	8 6	6 55	6 1	5 19	4 45	4 17	3 52	3 18	2 50	2 30	2 13	2 0	1 50	1 41	1 34	1 29	64
66			6 7	5 24	4 50	4 21	3 56	3 20	2 53	2 32	2 15	2 2	1 51	1 42	1 35	1 29	66
68					4 55	4 25	4 0	3 22	2 55	2 34	2 17	2 4	1 52	1 43	1 36	1 30	68
70							4 4	3 24	2 57	2 36	2 18	2 5	1 53	1 44	1 37	1 31	70
72								3 26	2 59	2 37	2 19	2 6	1 54	1 45	1 38	1 32	72
74									3 1	2 38	2 20	2 7	1 55	1 46	1 39	1 32	74
76										2 39	2 21	2 8	1 56	1 47	1 39	1 33	76
78											2 22	2 8	1 57	1 48	1 40	1 33	78
80												2 9	1 58	1 48	1 40	1 34	80
82													1 58	1 48	1 40	1 34	82
84														1 49	1 41	1 34	84
86															1 41	1 34	86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 56°.

☽'s App. Alt.	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	☽'s App. Alt.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ′	′ ″	′	°
6	4 37	4 54	5 10	5 26	5 56	6 25	6 52	7 15	7 37	7 58							6
7	3 57	4 11	4 25	4 38	5 3	5 29	5 52	6 12	6 31	6 48							7
8	3 26	3 38	3 51	4 3	4 26	4 47	5 5	5 23	5 40	5 55	6 8						8
9	3 1	3 12	3 23	3 33	3 53	4 12	4 30	4 46	5 0	5 13	5 25						9
10	2 43	2 53	3 2	3 11	3 28	3 45	4 1	4 15	4 27	4 39	4 50						10
11	2 29	2 37	2 45	2 53	3 9	3 24	3 38	3 50	4 1	4 12	4 21						11
12	2 16	2 23	2 30	2 38	2 52	3 6	3 18	3 28	3 38	3 47	3 56	4 4					12
13	2 6	2 12	2 18	2 25	2 37	2 50	3 1	3 10	3 19	3 28	3 36	3 42					13
14	1 57	2 3	2 8	2 14	2 25	2 36	2 47	2 56	3 4	3 12	3 19	3 24					14
15	1 50	1 55	1 59	2 5	2 15	2 25	2 35	2 44	2 51	2 58	3 4	3 10					15
16	1 44	1 48	1 53	1 58	2 7	2 16	2 25	2 33	2 39	2 45	2 51	2 57	3 2				16
17	1 39	1 43	1 48	1 52	2 0	2 8	2 16	2 24	2 30	2 35	2 40	2 45	2 49				17
18	1 35	1 39	1 43	1 47	1 54	2 1	2 8	2 15	2 21	2 26	2 31	2 35	2 38				18
19	1 31	1 35	1 38	1 42	1 48	1 55	2 1	2 7	2 13	2 18	2 23	2 27	2 30				19
20	1 28	1 31	1 34	1 37	1 43	1 49	1 55	2 0	2 6	2 10	2 15	2 19	2 22	2 24			20
21	1 25	1 27	1 30	1 33	1 38	1 44	1 49	1 54	1 59	2 3	2 7	2 11	2 14	2 16			21
22	1 22	1 24	1 27	1 30	1 34	1 39	1 44	1 48	1 52	1 56	2 0	2 4	2 6	2 8			22
23	1 20	1 22	1 24	1 27	1 31	1 35	1 40	1 44	1 47	1 51	1 54	1 57	2 0	2 2			23
24	1 19	1 20	1 22	1 25	1 28	1 32	1 36	1 40	1 43	1 46	1 49	1 52	1 54	1 56	1 58		24
25	1 18	1 19	1 21	1 23	1 26	1 29	1 33	1 36	1 39	1 42	1 44	1 47	1 49	1 51	1 53		25
26	1 17	1 18	1 19	1 21	1 24	1 27	1 30	1 33	1 35	1 38	1 40	1 42	1 44	1 46	1 48		26
27	1 16	1 17	1 18	1 19	1 22	1 25	1 27	1 30	1 32	1 35	1 37	1 39	1 40	1 42	1 44		27
28	1 16	1 16	1 17	1 18	1 20	1 23	1 25	1 27	1 29	1 32	1 34	1 36	1 37	1 39	1 40	1 41	28
29	1 15	1 15	1 16	1 17	1 19	1 21	1 23	1 25	1 27	1 29	1 31	1 33	1 34	1 35	1 36	1 37	29
30	1 15	1 15	1 16	1 16	1 17	1 19	1 21	1 23	1 25	1 27	1 29	1 30	1 31	1 32	1 33	1 34	30
31	1 14	1 14	1 15	1 15	1 16	1 18	1 19	1 21	1 23	1 25	1 27	1 28	1 29	1 29	1 30	1 31	31
32	1 14	1 14	1 14	1 14	1 15	1 17	1 18	1 19	1 21	1 23	1 25	1 26	1 27	1 27	1 27	1 28	32
33	1 14	1 13	1 13	1 13	1 14	1 16	1 17	1 18	1 20	1 21	1 23	1 24	1 25	1 25	1 25	1 26	33
34	1 14	1 13	1 13	1 13	1 14	1 15	1 16	1 17	1 19	1 20	1 21	1 22	1 23	1 23	1 23	1 24	34
35	1 14	1 13	1 13	1 13	1 13	1 14	1 15	1 16	1 17	1 18	1 19	1 20	1 21	1 21	1 21	1 22	35
36	1 14	1 13	1 12	1 12	1 12	1 13	1 14	1 15	1 16	1 16	1 17	1 18	1 19	1 19	1 19	1 20	36
37	1 14	1 13	1 12	1 12	1 12	1 12	1 13	1 14	1 15	1 15	1 16	1 16	1 17	1 17	1 17	1 18	37
38	1 14	1 13	1 12	1 11	1 11	1 12	1 13	1 13	1 14	1 14	1 15	1 15	1 16	1 16	1 16	1 17	38
39	1 14	1 13	1 12	1 11	1 11	1 11	1 12	1 12	1 13	1 13	1 13	1 13	1 14	1 14	1 15	1 15	39
40	1 14	1 13	1 12	1 11	1 10	1 10	1 11	1 11	1 12	1 12	1 12	1 12	1 12	1 13	1 13	1 13	40
41	1 15	1 14	1 12	1 11	1 10	1 10	1 10	1 10	1 11	1 11	1 11	1 11	1 11	1 12	1 12		41
42	1 15	1 14	1 12	1 11	1 9	1 9	1 9	1 9	1 10	1 10	1 10	1 10	1 10	1 11	1 11		42
43	1 15	1 14	1 12	1 11	1 9	1 9	1 9	1 9	1 9	1 9	1 9	1 9	1 9	1 10	1 10		43
44	1 16	1 14	1 12	1 11	1 9	1 8	1 8	1 8	1 8	1 8	1 8	1 8	1 8	1 9	1 9		44
46	1 17	1 15	1 13	1 12	1 9	1 7	1 7	1 7	1 6	1 6	1 6	1 7	1 7	1 7			46
48	1 17	1 15	1 13	1 12	1 9	1 7	1 6	1 6	1 5	1 5	1 5	1 5	1 5	1 6			48
50	1 18	1 16	1 14	1 12	1 9	1 6	1 5	1 5	1 4	1 4	1 4	1 4	1 4				50
52	1 19	1 17	1 15	1 13	1 9	1 6	1 4	1 4	1 3	1 3	1 3	1 3	1 3				52
54	1 20	1 17	1 15	1 13	1 9	1 6	1 4	1 3	1 3	1 2	1 2	1 2					54
56	1 21	1 18	1 16	1 14	1 10	1 6	1 4	1 2	1 2	1 1	1 1	1 1					56
58	1 22	1 19	1 16	1 14	1 10	1 6	1 4	1 2	1 1	1 0	1 0						58
60	1 23	1 19	1 16	1 14	1 10	1 6	1 4	1 2	1 1	1 0	1 0						60
62	1 24	1 20	1 17	1 14	1 10	1 6	1 4	1 2	1 1	1 0							62
64	1 24	1 20	1 17	1 14	1 11	7	1 4	1 2	1 0	1 0							64
66	1 25	1 21	1 18	1 15	1 11	7	1 4	1 2	1 0								66
68	1 25	1 21	1 18	1 15	1 11	1 7	1 4	1 2	1 0								68
70	1 26	1 22	1 19	1 16	1 11	1 7	1 4	1 2									70
72	1 27	1 23	1 19	1 16	1 11	1 7	1 4	1 2									72
74	1 27	1 23	1 19	1 16	1 11	1 7	1 4										74
76	1 28	1 23	1 19	1 16	1 11	1 7	1 4										76
78	1 28	1 23	1 20	1 17	1 11	1 7											78
80	1 29	1 24	1 20	1 17	1 11	1 7											80
82	1 29	1 24	1 20	1 17	1 11												82
84	1 29	1 24	1 20	1 17	1 11												84
86	1 29	1 24	1 20	1 17													86
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°						

Table P. Effect of Sun's Par.

Add the Numbers above the lines to Third Correction; subtract the others.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″		″	″
5	0	0	1	2	3	4	4			
10	1	1	0	1	2	2	3			
20	3	3	2	1	0	1	2	2		
30	5	4	3	2	1	1	0	0	1	
40	6	6	5	4	3	2	2	1	1	0
50	8	7	6	5	4	4	[illegible]	3		
60	9	8	7	6	5	5	4			
70		9	8	7	6	6				
80			8	8	7					
90				8						

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 60°

☽'s App Alt.	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	☽'s App Alt.
	Apparent Altitude of the Sun, Star or Planet.																
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 22	1 23	1 25	1 28	1 33	1 40	1 47	2 1	2 16	2 33	2 50	3 8	3 25	3 41	3 58	4 15	6
7	1 24	1 22	1 23	1 25	1 28	1 33	1 37	1 47	1 59	2 13	2 27	2 41	2 55	3 9	3 23	3 37	7
8	1 28	1 24	1 22	1 23	1 25	1 28	1 31	1 39	1 48	1 59	2 11	2 23	2 35	2 48	3 0	3 12	8
9	1 33	1 28	1 24	1 22	1 24	1 25	1 27	1 33	1 40	1 49	1 58	2 8	2 18	2 29	2 39	2 50	9
10	1 40	1 33	1 27	1 24	1 23	1 24	1 25	1 29	1 34	1 41	1 49	1 57	2 6	2 15	2 25	2 34	10
11	1 47	1 38	1 31	1 27	1 24	1 23	1 24	1 26	1 30	1 36	1 42	1 49	1 57	2 5	2 13	2 21	11
12	1 55	1 43	1 36	1 30	1 26	1 24	1 23	1 25	1 28	1 32	1 37	1 43	1 49	1 56	2 3	2 11	12
13	2 3	1 49	1 40	1 34	1 29	1 26	1 24	1 24	1 26	1 29	1 33	1 38	1 43	1 49	1 55	2 2	13
14	2 10	1 55	1 45	1 38	1 32	1 28	1 25	1 23	1 25	1 27	1 30	1 34	1 38	1 43	1 49	1 54	14
15	2 18	2 1	1 50	1 42	1 36	1 31	1 27	1 24	1 23	1 25	1 27	1 30	1 34	1 38	1 43	1 48	15
16	2 26	2 7	1 55	1 46	1 39	1 34	1 29	1 25	1 22	1 23	1 25	1 27	1 30	1 34	1 38	1 43	16
17	2 34	2 13	2 0	1 50	1 43	1 37	1 31	1 26	1 22	1 22	1 23	1 25	1 28	1 31	1 34	1 38	17
18	2 42	2 20	2 5	1 54	1 46	1 40	1 34	1 27	1 23	1 21	1 22	1 23	1 25	1 28	1 31	1 34	18
19	2 50	2 27	2 11	1 59	1 50	1 43	1 36	1 29	1 24	1 22	1 21	1 22	1 23	1 26	1 28	1 31	19
20	2 59	2 34	2 17	2 4	1 54	1 46	1 39	1 31	1 25	1 22	1 20	1 21	1 22	1 24	1 26	1 28	20
21	3 7	2 41	2 23	2 9	1 58	1 50	1 42	1 33	1 26	1 23	1 21	1 20	1 21	1 22	1 24	1 25	21
22	3 15	2 48	2 29	2 14	2 2	1 53	1 45	1 35	1 28	1 24	1 21	1 20	1 20	1 21	1 22	1 23	22
23	3 24	2 55	2 35	2 19	2 7	1 57	1 48	1 37	1 30	1 25	1 22	1 20	1 20	1 20	1 21	1 22	23
24	3 32	3 2	2 41	2 24	2 10	2 1	1 52	1 40	1 31	1 26	1 23	1 21	1 20	1 20	1 20	1 21	24
25	3 41	3 9	2 47	2 29	2 15	2 4	1 55	1 42	1 33	1 27	1 24	1 22	1 20	1 19	1 19	1 20	25
26	3 49	3 16	2 53	2 34	2 20	2 8	1 59	1 45	1 35	1 29	1 25	1 22	1 20	1 19	1 19	1 19	26
27	3 58	3 23	2 59	2 39	2 25	2 12	2 3	1 48	1 38	1 31	1 26	1 23	1 21	1 19	1 19	1 19	27
28	4 6	3 30	3 5	2 44	2 29	2 16	2 7	1 51	1 40	1 32	1 27	1 23	1 21	1 19	1 18	1 18	28
29	4 15	3 37	3 11	2 49	2 33	2 20	2 11	1 53	1 42	1 34	1 28	1 24	1 21	1 19	1 18	1 18	29
30	4 23	3 44	3 17	2 54	2 38	2 24	2 14	1 56	1 44	1 35	1 29	1 24	1 21	1 19	1 18	1 18	30
31	4 31	3 51	3 23	2 59	2 42	2 28	2 18	1 59	1 46	1 37	1 30	1 25	1 22	1 20	1 18	1 18	31
32	4 39	3 58	3 29	3 4	2 47	2 32	2 21	2 2	1 48	1 38	1 31	1 26	1 22	1 20	1 19	1 18	32
33	4 47	4 5	3 34	3 9	2 52	2 36	2 25	2 5	1 51	1 40	1 33	1 27	1 23	1 20	1 19	1 18	33
34	4 55	4 12	3 40	3 14	2 56	2 40	2 28	2 8	1 53	1 41	1 34	1 28	1 24	1 21	1 19	1 18	34
35	5 3	4 18	3 46	3 19	3 0	2 44	2 32	2 11	1 55	1 43	1 35	1 29	1 25	1 22	1 20	1 18	35
36	5 10	4 24	3 52	3 24	3 4	2 48	2 35	2 14	1 57	1 45	1 37	1 31	1 26	1 22	1 20	1 18	36
37	5 18	4 31	3 58	3 29	3 8	2 52	2 39	2 17	1 59	1 47	1 38	1 32	1 27	1 23	1 21	1 19	37
38	5 25	4 38	4 4	3 34	3 12	2 55	2 42	2 20	2 2	1 49	1 40	1 33	1 28	1 24	1 21	1 19	38
39	5 32	4 45	4 10	3 39	3 17	2 59	2 46	2 22	2 4	1 51	1 42	1 35	1 29	1 25	1 22	1 20	39
40	5 39	4 51	4 15	3 44	3 21	3 3	2 49	2 25	2 6	1 53	1 43	1 36	1 30	1 26	1 22	1 20	40
41	5 46	4 57	4 21	3 49	3 26	3 7	2 52	2 27	2 8	1 55	1 45	1 37	1 31	1 27	1 23	1 20	41
42	5 53	5 3	4 26	3 53	3 30	3 11	2 55	2 30	2 10	1 56	1 46	1 38	1 32	1 28	1 24	1 21	42
43	6 0	5 9	4 31	3 58	3 35	3 15	2 58	2 32	2 13	1 58	1 48	1 40	1 34	1 29	1 25	1 22	43
44	6 7	5 15	4 36	4 3	3 39	3 19	3 1	2 35	2 15	2 0	1 49	1 41	1 35	1 30	1 26	1 22	44
46	6 21	5 26	4 46	4 12	3 47	3 26	3 7	2 40	2 19	2 4	1 52	1 43	1 37	1 31	1 27	1 23	46
48	6 34	5 37	4 55	4 20	3 54	3 32	3 13	2 45	2 23	2 8	1 56	1 46	1 39	1 33	1 28	1 24	48
50	6 47	5 48	5 4	4 28	4 1	3 37	3 19	2 50	2 27	2 11	1 59	1 48	1 41	1 35	1 29	1 25	50
52	6 59	5 58	5 13	4 36	4 8	3 43	3 25	2 55	2 31	2 14	2 2	1 51	1 43	1 36	1 31	1 27	52
54	7 11	6 8	5 22	4 44	4 15	3 49	3 30	2 59	2 35	2 18	2 4	1 53	1 45	1 38	1 33	1 28	54
56	7 22	6 17	5 30	4 51	4 21	3 55	3 35	3 4	2 38	2 21	2 7	1 56	1 47	1 40	1 34	1 29	56
58	7 31	6 25	5 37	4 58	4 27	4 1	3 40	3 8	2 41	2 24	2 10	1 58	1 49	1 41	1 35	1 30	58
60	7 40	6 32	5 45	5 4	4 32	4 6	3 45	3 12	2 44	2 27	2 12	2 0	1 50	1 42	1 36	1 31	60
62	7 48	6 39	5 52	5 10	4 38	4 11	3 50	3 16	2 48	2 29	2 14	2 2	1 52	1 44	1 37	1 32	62
64	7 56	6 46	5 58	5 15	4 43	4 15	3 55	3 19	2 51	2 31	2 16	2 4	1 53	1 45	1 38	1 33	64
66	8 3	6 53	6 2	5 20	4 47	4 19	3 59	3 22	2 54	2 33	2 18	2 5	1 55	1 46	1 39	1 34	66
68	8 10	6 59	6 6	5 24	4 51	4 23	4 2	3 25	2 56	2 35	2 19	2 6	1 56	1 47	1 40	1 34	68
70			6 10	5 27	4 54	4 26	4 4	3 27	2 58	2 36	2 20	2 7	1 57	1 48	1 41	1 35	70
72					4 57	4 29	4 6	3 28	3 0	2 38	2 21	2 8	1 58	1 49	1 41	1 35	72
74							4 8	3 29	3 2	2 39	2 22	2 9	1 59	1 50	1 42	1 36	74
76								3 30	3 3	2 41	2 23	2 10	1 59	1 50	1 42	1 36	76
78									3 4	2 42	2 24	2 11	2 0	1 51	1 43	1 37	78
80										2 43	2 25	2 12	2 1	1 51	1 43	1 37	80
82											2 26	2 12	2 1	1 52	1 44	1 38	82
84												2 12	2 2	1 52	1 44	1 38	84
86													2 2	1 52	1 44	1 38	86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 60°.

Apparent Altitude of the Sun, Star or Planet.

☽'s App. Alt.	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	☽'s App. Alt.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	4 32	4 48	5 3	5 19	5 49	6 17	6 44	7 7	7 28	7 47	8 3						6
7	3 51	4 5	4 19	4 32	4 58	5 22	5 44	6 4	6 22	6 38	6 53						7
8	3 23	3 35	3 47	3 59	4 22	4 42	5 1	5 19	5 35	5 50	6 2	6 13					8
9	3 0	3 10	3 20	3 30	3 49	4 8	4 25	4 41	4 55	5 8	5 19	5 30					9
10	2 43	2 51	3 0	3 9	3 26	3 42	3 58	4 12	4 24	4 35	4 45	4 54					10
11	2 29	2 37	2 44	2 52	3 7	3 21	3 35	3 48	3 59	4 9	4 18	4 26					11
12	2 18	2 25	2 32	2 39	2 52	3 5	3 17	3 29	3 39	3 48	3 56	4 3	4 8				12
13	2 8	2 15	2 21	2 28	2 39	2 51	3 2	3 12	3 21	3 30	3 38	3 44	3 48				13
14	2 0	2 6	2 12	2 18	2 28	2 38	2 48	2 57	3 6	3 14	3 21	3 26	3 29				14
15	1 53	1 58	2 3	2 8	2 18	2 27	2 36	2 45	2 53	3 0	3 6	3 11	3 15				15
16	1 47	1 51	1 55	2 0	2 9	2 18	2 26	2 34	2 41	2 48	2 53	2 58	3 2	3 6			16
17	1 42	1 45	1 49	1 53	2 1	2 9	2 17	2 24	2 31	2 37	2 42	2 46	2 50	2 53			17
18	1 37	1 40	1 44	1 47	1 54	2 1	2 9	2 16	2 22	2 27	2 32	2 36	2 40	2 42			18
19	1 33	1 36	1 39	1 42	1 48	1 55	2 2	2 9	2 15	2 19	2 24	2 28	2 31	2 33			19
20	1 30	1 32	1 35	1 38	1 44	1 50	1 56	2 2	2 8	2 12	2 16	2 20	2 23	2 25	2 27		20
21	1 27	1 29	1 32	1 35	1 40	1 46	1 51	1 56	2 1	2 6	2 10	2 13	2 15	2 17	2 19		21
22	1 25	1 27	1 29	1 32	1 37	1 42	1 47	1 51	1 56	2 0	2 4	2 6	2 8	2 10	2 12		22
23	1 23	1 25	1 27	1 30	1 34	1 38	1 43	1 47	1 51	1 55	1 59	2 1	2 3	2 4	2 6		23
24	1 22	1 23	1 25	1 27	1 31	1 35	1 40	1 44	1 47	1 51	1 54	1 56	1 58	1 59	2 1	2 3	24
25	1 21	1 22	1 23	1 25	1 29	1 32	1 36	1 40	1 43	1 47	1 49	1 51	1 53	1 54	1 56	1 57	25
26	1 20	1 21	1 22	1 23	1 26	1 29	1 33	1 37	1 40	1 43	1 45	1 47	1 49	1 50	1 51	1 52	26
27	1 19	1 20	1 21	1 22	1 24	1 27	1 30	1 34	1 37	1 40	1 42	1 43	1 45	1 46	1 47	1 48	27
28	1 19	1 19	1 20	1 21	1 23	1 25	1 28	1 31	1 34	1 37	1 39	1 40	1 41	1 42	1 43	1 44	28
29	1 18	1 18	1 19	1 20	1 22	1 23	1 26	1 29	1 31	1 34	1 36	1 37	1 38	1 39	1 40	1 41	29
30	1 18	1 18	1 18	1 19	1 20	1 22	1 24	1 27	1 29	1 31	1 33	1 34	1 35	1 36	1 37	1 38	30
31	1 18	1 18	1 18	1 18	1 19	1 20	1 22	1 25	1 27	1 29	1 30	1 31	1 32	1 33	1 34	1 35	31
32	1 17	1 17	1 17	1 17	1 18	1 19	1 21	1 23	1 25	1 27	1 28	1 29	1 30	1 31	1 31	1 32	32
33	1 17	1 16	1 16	1 16	1 17	1 18	1 19	1 21	1 23	1 25	1 26	1 27	1 28	1 29	1 29	1 30	33
34	1 17	1 16	1 16	1 16	1 16	1 17	1 18	1 20	1 22	1 23	1 24	1 25	1 26	1 27	1 27	1 28	34
35	1 17	1 16	1 16	1 16	1 16	1 16	1 17	1 18	1 20	1 21	1 22	1 23	1 24	1 25	1 25	1 26	35
36	1 17	1 16	1 15	1 16	1 16	1 16	1 16	1 17	1 18	1 19	1 20	1 21	1 22	1 23	1 23	1 24	36
37	1 17	1 16	1 15	1 15	1 15	1 15	1 15	1 16	1 17	1 18	1 19	1 20	1 21	1 21	1 22		37
38	1 17	1 16	1 15	1 14	1 14	1 14	1 14	1 15	1 16	1 17	1 18	1 19	1 20	1 20	1 21		38
39	1 18	1 16	1 15	1 14	1 13	1 13	1 13	1 14	1 15	1 16	1 17	1 17	1 18	1 18	1 19		39
40	1 18	1 16	1 15	1 14	1 13	1 13	1 13	1 14	1 14	1 15	1 16	1 16	1 17	1 17	1 17		40
41	1 18	1 16	1 15	1 14	1 12	1 12	1 12	1 13	1 13	1 14	1 15	1 15	1 16	1 16			41
42	1 18	1 16	1 15	1 14	1 12	1 12	1 12	1 12	1 12	1 13	1 14	1 14	1 15	1 15			42
43	1 19	1 17	1 16	1 14	1 12	1 11	1 11	1 11	1 11	1 12	1 13	1 13	1 14	1 14			43
44	1 19	1 17	1 16	1 14	1 12	1 11	1 11	1 11	1 11	1 11	1 12	1 12	1 13	1 13			44
46	1 20	1 18	1 16	1 14	1 12	1 11	1 10	1 10	1 10	1 10	1 11	1 11	1 11				46
48	1 21	1 19	1 17	1 15	1 12	1 10	1 9	1 9	1 9	1 9	1 10	1 10	1 10				48
50	1 22	1 19	1 17	1 15	1 12	1 10	1 9	1 8	1 8	1 8	1 8	1 8					50
52	1 23	1 20	1 17	1 15	1 12	1 10	1 8	1 8	1 8	1 7	1 7	1 7					52
54	1 24	1 21	1 18	1 16	1 13	1 10	1 8	1 7	1 7	1 6	1 6						54
56	1 25	1 22	1 19	1 16	1 13	1 10	1 8	1 7	1 7	1 6	1 6						56
58	1 26	1 23	1 20	1 17	1 13	1 10	1 8	1 7	1 6	1 5							
60	1 27	1 24	1 21	1 18	1 14	1 10	1 8	1 7	1 6	1 5							
62	1 28	1 24	1 21	1 18	1 14	1 10	1 8	1 6	1 5								
64	1 29	1 25	1 21	1 18	1 14	1 10	1 8	1 6	1 5								
66	1 29	1 25	1 21	1 18	1 14	1 11	1 8	1 6									
68	1 29	1 25	1 22	1 19	1 15	1 11	1 8	1 6									
70	1 30	1 26	1 22	1 19	1 15	1 11	1 8										
72	1 30	1 26	1 23	1 20	1 15	1 11	1 8										
74	1 31	1 27	1 23	1 20	1 15	1 11											
76	1 31	1 27	1 23	1 20	1 15	1 11											
78	1 32	1 28	1 24	1 20	1 15												
80	1 32	1 28	1 24	1 21	1 15												
82	1 33	1 28	1 24	1 21													
84	1 33	1 28	1 24	1 21													
86	1 33	1 28	1 24														
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°						

Table P. ***Effect of Sun's Par.***

Add the Numbers above the lines to Third Correction; subtract the others.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	0	0	1	2	3	3	4			
10	1	1	[illegible]	1	2	2	3	3		
20	3	3	2	1	0	0	1	1	2	
30	5	4	3	3	2	2	1	1	0	
40	6	6	5	4	3	3	2	2	2	..
50	7	7	6	5	5	4	3	3		
60	8	8	7	6	6	5	4			
70		9	8	7	6	6				
80			8	8	7					
90				[illegible]						

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 64°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 26	1 27	1 29	1 32	1 36	1 42	1 49	2 3	2 19	2 35	2 51	3 8	3 24	3 40	3 56	4 12	5
7	1 28	1 26	1 27	1 29	1 32	1 35	1 40	1 51	2 3	2 15	2 28	2 42	2 56	3 9	3 22	3 36	7
8	1 32	1 28	1 26	1 27	1 29	1 31	1 34	1 42	1 51	2 2	2 13	2 24	2 36	2 48	3 0	3 11	8
9	1 37	1 31	1 28	1 26	1 27	1 28	1 30	1 36	1 43	1 52	2 1	2 10	2 20	2 31	2 41	2 51	9
10	1 43	1 35	1 30	1 27	1 26	1 27	1 28	1 32	1 37	1 44	1 51	1 59	2 8	2 17	2 26	2 35	10
11	1 50	1 40	1 33	1 29	1 27	1 26	1 27	1 29	1 33	1 38	1 44	1 51	1 59	2 7	2 14	2 22	11
12	1 57	1 45	1 37	1 32	1 29	1 27	1 26	1 28	1 30	1 34	1 38	1 44	1 51	1 58	2 5	2 12	12
13	2 4	1 50	1 41	1 35	1 31	1 29	1 27	1 27	1 28	1 31	1 34	1 38	1 44	1 50	1 57	2 3	13
14	2 12	1 56	1 46	1 39	1 34	1 31	1 29	1 26	1 27	1 29	1 31	1 34	1 39	1 44	1 50	1 55	14
15	2 20	2 2	1 51	1 43	1 37	1 33	1 30	1 27	1 26	1 27	1 29	1 31	1 35	1 40	1 44	1 49	15
16	2 27	2 8	1 56	1 47	1 41	1 36	1 32	1 28	1 25	1 26	1 27	1 29	1 32	1 36	1 40	1 44	16
17	2 35	2 14	2 1	1 51	1 45	1 39	1 34	1 29	1 26	1 25	1 26	1 28	1 30	1 33	1 36	1 40	17
18	2 43	2 21	2 6	1 56	1 48	1 42	1 37	1 31	1 27	1 25	1 25	1 26	1 28	1 30	1 33	1 36	18
19	2 51	2 27	2 12	2 0	1 52	1 45	1 39	1 32	1 28	1 25	1 25	1 25	1 27	1 26	1 30	1 33	19
20	2 59	2 34	2 17	2 5	1 56	1 49	1 42	1 34	1 29	1 26	1 24	1 24	1 25	1 26	1 28	1 30	20
21	3 7	2 41	2 23	2 10	2 0	1 52	1 45	1 36	1 30	1 26	1 24	1 23	1 24	1 25	1 26	1 28	21
22	3 15	2 48	2 29	2 15	2 4	1 55	1 48	1 38	1 31	1 27	1 25	1 23	1 23	1 24	1 25	1 26	22
23	3 23	2 55	2 35	2 20	2 8	1 59	1 51	1 40	1 33	1 28	1 25	1 23	1 23	1 24	1 24	1 25	23
24	3 31	3 2	2 41	2 25	2 12	2 2	1 54	1 42	1 34	1 29	1 26	1 24	1 23	1 23	1 24	1 25	24
25	3 39	3 8	2 47	2 30	2 17	2 6	1 57	1 44	1 36	1 30	1 26	1 24	1 23	1 23	1 23	1 24	25
26	3 47	3 15	2 53	2 35	2 21	2 10	2 0	1 47	1 38	1 32	1 27	1 25	1 23	1 23	1 23	1 23	26
27	3 56	3 22	2 59	2 40	2 26	2 14	2 4	1 50	1 40	1 33	1 28	1 25	1 23	1 23	1 22	1 23	27
28	4 4	3 29	3 5	2 45	2 30	2 18	2 7	1 53	1 42	1 35	1 29	1 26	1 24	1 23	1 22	1 22	28
29	4 12	3 36	3 11	2 50	2 35	2 22	2 11	1 55	1 44	1 36	1 30	1 27	1 25	1 23	1 22	1 22	29
30	4 20	3 42	3 17	2 55	2 39	2 26	2 15	1 58	1 46	1 38	1 32	1 28	1 25	1 24	1 23	1 22	30
31	4 28	3 49	3 23	3 0	2 43	2 30	2 18	2 0	1 48	1 40	1 33	1 29	1 26	1 24	1 23	1 22	31
32	4 36	3 55	3 28	3 5	2 48	2 34	2 22	2 3	1 50	1 41	1 34	1 30	1 26	1 24	1 23	1 22	32
33	4 44	4 2	3 34	3 10	2 52	2 38	2 26	2 6	1 53	1 43	1 36	1 30	1 27	1 24	1 23	1 22	33
34	4 52	4 8	3 39	3 15	2 56	2 41	2 29	2 8	1 55	1 44	1 37	1 31	1 28	1 25	1 23	1 22	34
35	5 0	4 15	3 45	3 20	3 1	2 45	2 33	2 11	1 57	1 46	1 38	1 32	1 28	1 25	1 23	1 22	35
36	5 7	4 21	3 51	3 25	3 5	2 49	2 36	2 14	1 59	1 47	1 39	1 33	1 29	1 26	1 24	1 23	36
37	5 14	4 28	3 57	3 30	3 9	2 53	2 40	2 17	2 2	1 49	1 41	1 34	1 30	1 27	1 25	1 23	37
38	5 21	4 34	4 2	3 35	3 14	2 57	2 43	2 20	2 4	1 52	1 43	1 36	1 31	1 27	1 25	1 23	38
39	5 28	4 41	4 7	3 39	3 18	3 1	2 46	2 23	2 6	1 54	1 45	1 37	1 32	1 28	1 25	1 23	39
40	5 35	4 47	4 12	3 44	3 22	3 4	2 49	2 26	2 9	1 56	1 46	1 38	1 33	1 29	1 26	1 24	40
41	5 42	4 53	4 17	3 49	3 26	3 8	2 52	2 29	2 11	1 58	1 48	1 40	1 34	1 29	1 26	1 24	41
42	5 49	4 59	4 22	3 53	3 30	3 11	2 55	2 31	2 13	2 0	1 49	1 41	1 35	1 30	1 27	1 24	42
43	5 56	5 5	4 27	3 58	3 34	3 15	2 59	2 34	2 15	2 2	1 51	1 42	1 36	1 31	1 28	1 25	43
44	6 2	5 11	4 32	4 3	3 38	3 19	3 2	2 36	2 17	2 3	1 52	1 44	1 38	1 32	1 29	1 26	44
46	6 15	5 21	4 42	4 11	3 45	3 26	3 8	2 41	2 22	2 6	1 55	1 47	1 40	1 34	1 30	1 27	46
48	6 28	5 32	4 52	4 19	3 53	3 32	3 14	2 45	2 26	2 10	1 58	1 49	1 42	1 36	1 32	1 28	48
50	6 40	5 42	5 1	4 27	4 0	3 38	3 20	2 50	2 29	2 14	2 1	1 51	1 44	1 37	1 33	1 29	50
52	6 52	5 52	5 10	4 35	4 7	3 44	3 25	2 55	2 33	2 17	2 4	1 54	1 46	1 39	1 34	1 30	52
54	7 3	6 1	5 18	4 42	4 14	3 50	3 30	2 59	2 37	2 20	2 7	1 56	1 48	1 41	1 35	1 31	54
56	7 14	6 10	5 26	4 49	4 20	3 55	3 35	3 3	2 41	2 23	2 9	1 58	1 49	1 43	1 37	1 32	56
58	7 24	6 18	5 34	4 56	4 25	4 0	3 39	3 7	2 44	2 26	2 11	2 0	1 52	1 45	1 38	1 33	58
60	7 32	6 26	5 41	5 2	4 30	4 5	3 44	3 11	2 47	2 29	2 14	2 2	1 54	1 47	1 40	1 35	60
62	7 40	6 33	5 47	5 7	4 35	4 10	3 49	3 15	2 50	2 31	2 16	2 4	1 55	1 48	1 41	1 36	62
64	7 48	6 40	5 53	5 12	4 40	4 15	3 53	3 19	2 52	2 34	2 19	2 6	1 56	1 49	1 42	1 37	64
66	7 55	6 47	5 59	5 17	4 45	4 19	3 57	3 22	2 54	2 36	2 21	2 8	1 57	1 50	1 43	1 38	66
68	8 1	6 53	6 4	5 22	4 49	4 23	4 1	3 24	2 56	2 38	2 22	2 9	1 59	1 51	1 44	1 38	68
70	8 7	6 59	6 8	5 26	4 53	4 26	4 4	3 26	2 58	2 40	2 23	2 10	2 0	1 52	1 45	1 39	70
72	8 12	7 4	6 11	5 30	4 56	4 29	4 6	3 28	3 0	2 41	2 24	2 11	2 1	1 53	1 46	1 39	72
74			6 14	5 33	4 59	4 31	4 8	3 30	3 2	2 42	2 25	2 12	2 2	1 54	1 47	1 40	74
76					5 1	4 33	4 9	3 32	3 4	2 43	2 26	2 13	2 3	1 54	1 47	1 40	76
78							4 10	3 33	3 6	2 44	2 27	2 14	2 3	1 54	1 47	1 41	78
80								3 34	3 7	2 45	2 28	2 15	2 4	1 55	1 47	1 41	80
82									3 8	2 46	2 29	2 16	2 4	1 55	1 48	1 42	82
84										2 47	2 29	2 16	2 5	1 56	1 49	1 42	84
86											2 29	2 16	2 6	1 56	1 49	1 42	86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 64°.

☽'s App. Alt.	*Apparent Altitude of the Sun, Star or Planet.*																☽'s App Alt.
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	4 29	4 45	5 0	5 15	5 43	6 10	6 36	6 59	7 20	7 39	7 54	8 7					6
7	3 49	4 2	4 15	4 28	4 53	5 16	5 37	5 57	6 15	6 32	6 46	6 59					7
8	3 22	3 34	3 45	3 56	4 18	4 38	4 57	5 15	5 31	5 46	5 58	6 7	6 16				8
9	3 0	3 10	3 20	3 30	3 49	4 7	4 23	4 38	4 52	5 5	5 16	5 26	5 34				9
10	2 43	2 52	3 1	3 10	3 27	3 42	3 56	4 9	4 21	4 32	4 42	4 51	4 59				10
11	2 30	2 37	2 45	2 54	3 9	3 22	3 35	3 47	3 57	4 7	4 16	4 24	4 31				11
12	2 19	2 25	2 33	2 40	2 53	3 5	3 17	3 27	3 37	3 47	3 56	4 3	4 8	4 13			12
13	2 9	2 15	2 22	2 28	2 40	2 51	3 1	3 11	3 20	3 29	3 37	3 43	3 47	3 51			13
14	2 1	2 7	2 13	2 18	2 29	2 39	2 48	2 57	3 6	3 14	3 20	3 25	3 29	3 33			14
15	1 54	2 0	2 5	2 10	2 19	2 29	2 37	2 45	2 53	3 0	3 5	3 10	3 14	3 18			15
16	1 48	1 53	1 58	2 3	2 11	2 20	2 28	2 35	2 42	2 48	2 53	2 57	3 1	3 5	3 8		16
17	1 43	1 47	1 52	1 56	2 4	2 12	2 20	2 26	2 32	2 38	2 43	2 47	2 51	2 54	2 56		17
18	1 39	1 43	1 47	1 50	1 58	2 5	2 12	2 18	2 24	2 30	2 35	2 39	2 42	2 44	2 46		18
19	1 36	1 39	1 42	1 46	1 52	1 59	2 5	2 11	2 17	2 22	2 27	2 31	2 34	2 36	2 38		19
20	1 33	1 36	1 38	1 42	1 48	1 54	1 59	2 5	2 11	2 15	2 20	2 23	2 26	2 28	2 30	2 32	20
21	1 30	1 33	1 35	1 38	1 44	1 49	1 54	2 0	2 5	2 9	2 13	2 16	2 18	2 20	2 22	2 23	21
22	1 28	1 30	1 33	1 35	1 40	1 45	1 50	1 55	1 59	2 3	2 6	2 9	2 11	2 13	2 15	2 16	22
23	1 27	1 28	1 30	1 32	1 37	1 41	1 46	1 51	1 54	1 58	2 1	2 3	2 5	2 7	2 9	2 10	23
24	1 26	1 27	1 28	1 30	1 34	1 38	1 42	1 47	1 50	1 54	1 57	1 59	2 0	2 2	2 4	2 5	24
25	1 25	1 26	1 27	1 28	1 32	1 35	1 39	1 43	1 47	1 50	1 53	1 55	1 56	1 58	1 59	2 0	25
26	1 24	1 25	1 26	1 27	1 30	1 33	1 36	1 40	1 44	1 47	1 49	1 51	1 52	1 54	1 55	1 56	26
27	1 23	1 24	1 25	1 26	1 28	1 31	1 34	1 37	1 41	1 44	1 46	1 47	1 49	1 50	1 51	1 52	27
28	1 23	1 23	1 24	1 25	1 26	1 29	1 32	1 35	1 38	1 41	1 43	1 44	1 45	1 46	1 47	1 48	28
29	1 22	1 22	1 23	1 24	1 25	1 27	1 30	1 32	1 35	1 38	1 40	1 41	1 42	1 43	1 44	1 45	29
30	1 22	1 22	1 23	1 23	1 24	1 26	1 28	1 30	1 33	1 35	1 37	1 38	1 39	1 40	1 41	1 42	30
31	1 22	1 22	1 22	1 22	1 23	1 24	1 26	1 28	1 31	1 33	1 34	1 35	1 36	1 37	1 38	1 40	31
32	1 21	1 21	1 21	1 21	1 22	1 23	1 25	1 27	1 29	1 31	1 32	1 33	1 34	1 35	1 36	1 38	32
33	1 21	1 21	1 21	1 21	1 21	1 22	1 24	1 26	1 27	1 29	1 30	1 31	1 32	1 33	1 34		33
34	1 21	1 20	1 20	1 20	1 20	1 21	1 23	1 25	1 26	1 27	1 28	1 29	1 30	1 31	1 32		34
35	1 21	1 20	1 20	1 20	1 20	1 21	1 22	1 23	1 24	1 25	1 26	1 27	1 28	1 29	1 30		35
36	1 21	1 20	1 19	1 19	1 19	1 20	1 21	1 22	1 23	1 24	1 25	1 26	1 26	1 27	1 28		36
37	1 21	1 20	1 19	1 19	1 19	1 19	1 20	1 21	1 22	1 23	1 24	1 25	1 25	1 26			37
38	1 21	1 20	1 19	1 18	1 18	1 18	1 19	1 20	1 21	1 22	1 23	1 24	1 24	1 25			38
39	1 21	1 20	1 19	1 18	1 18	1 18	1 18	1 19	1 20	1 21	1 21	1 22	1 22	1 23			39
40	1 22	1 20	1 19	1 18	1 17	1 17	1 18	1 18	1 19	1 20	1 20	1 21	1 21	1 22			40
41	1 22	1 20	1 19	1 18	1 17	1 17	1 17	1 17	1 18	1 19	1 19	1 20	1 20				41
42	1 22	1 20	1 19	1 18	1 16	1 16	1 16	1 17	1 17	1 18	1 18	1 19	1 19				42
43	1 23	1 21	1 19	1 18	1 16	1 16	1 16	1 16	1 16	1 17	1 17	1 18	1 18				43
44	1 23	1 21	1 19	1 18	1 16	1 16	1 16	1 16	1 16	1 16	1 16	1 17	1 17				44
46	1 24	1 22	1 20	1 18	1 16	1 15	1 15	1 15	1 15	1 15	1 15	1 16					46
48	1 25	1 22	1 20	1 19	1 16	1 15	1 15	1 14	1 14	1 14	1 14	1 14					48
50	1 26	1 23	1 21	1 19	1 16	1 15	1 14	1 13	1 13	1 13	1 13						50
52	1 27	1 24	1 22	1 20	1 17	1 15	1 13	1 12	1 12	1 12	1 12						52
54	1 28	1 25	1 22	1 20	1 17	1 15	1 13	1 12	1 11	1 11							54
56	1 29	1 26	1 23	1 21	1 17	1 15	1 13	1 12	1 11	1 11							56
58	1 29	1 26	1 23	1 21	1 18	1 15	1 13	1 11	1 10								
60	1 30	1 27	1 24	1 22	1 18	1 15	1 13	1 11	1 10								
62	1 31	1 28	1 25	1 22	1 18	1 15	1 13	1 11									
64	1 32	1 28	1 25	1 22	1 18	1 15	1 13	1 11									
66	1 33	1 29	1 26	1 23	1 18	1 16	1 13										
68	1 33	1 29	1 26	1 23	1 19	1 16	1 13										
70	1 34	1 30	1 27	1 24	1 19	1 16											
72	1 34	1 30	1 27	1 24	1 19	1 16											
74	1 35	1 31	1 28	1 24	1 19												
76	1 35	1 31	1 28	1 25	1 20												
78	1 36	1 32	1 28	1 25													
80	1 36	1 32	1 28	1 25													
82	1 37	1 32	1 28														
84	1 37	1 32															
86	1 37																
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°						

Table P. Effect of Sun's Par

Add the Numbers above the lines to Third Correction; subtract the others.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″		″	″	″
5	0	0	1	1	2	3	3	3		
10	1	1	0	0	1	2	2	2		
20	3	3	2	1	1	0	0	1	1	
30	5	4	3	3	2	2	1	1	1	0
40	6	6	5	4	4	3	3	2	2	
50	7	7	6	5	5	4	4	4		
60	8	8	7	6	6	5	5			
70	9	9	8	7	7	6				
80			8	8	7					
90				2						

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 68°.

☽'s App. Alt.	*Apparent Altitude of the Sun, Star or Planet.*																☽'s App. Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 29	1 31	1 34	1 37	1 41	1 46	1 52	2 6	2 21	2 36	2 52	3 8	3 24	3 39	3 54	4 10	6
7	1 32	1 29	1 31	1 33	1 36	1 39	1 43	1 54	2 5	2 17	2 30	2 43	2 50	3 9	3 22	3 36	7
8	1 36	1 31	1 29	1 30	1 32	1 34	1 37	1 45	1 54	2 4	2 14	2 25	2 37	2 48	2 59	3 11	8
9	1 41	1 34	1 31	1 29	1 30	1 31	1 33	1 38	1 46	1 54	2 3	2 12	2 22	2 32	2 42	2 52	9
10	1 46	1 38	1 33	1 30	1 29	1 30	1 31	1 14	1 40	1 47	1 54	2 2	2 10	2 19	2 28	2 36	10
11	1 52	1 43	1 36	1 32	1 30	1 29	1 30	1 32	1 36	1 41	1 47	1 54	2 1	2 9	2 16	2 24	11
12	1 59	1 48	1 40	1 35	1 32	1 30	1 29	1 30	1 33	1 37	1 42	1 48	1 54	2 0	2 7	2 14	12
13	2 6	1 53	1 44	1 38	1 34	1 32	1 30	1 29	1 31	1 34	1 38	1 43	1 48	1 53	1 59	2 5	13
14	2 14	1 59	1 49	1 42	1 37	1 34	1 31	1 29	1 30	1 32	1 35	1 39	1 44	1 48	1 53	1 58	14
15	2 21	2 5	1 54	1 46	1 40	1 36	1 33	1 30	1 30	1 31	1 33	1 36	1 40	1 44	1 48	1 53	15
16	2 28	2 11	1 59	1 50	1 44	1 39	1 35	1 31	1 29	1 30	1 32	1 34	1 37	1 40	1 44	1 48	16
17	2 36	2 17	2 4	1 54	1 47	1 42	1 38	1 32	1 29	1 29	1 30	1 32	1 34	1 37	1 40	1 44	17
18	2 41	2 24	2 10	1 59	1 51	1 45	1 40	1 34	1 30	1 28	1 29	1 30	1 32	1 35	1 37	1 40	18
19	2 52	2 30	2 15	2 4	1 55	1 48	1 43	1 35	1 31	1 28	1 28	1 29	1 31	1 33	1 35	1 37	19
20	3 0	2 36	2 21	2 8	1 59	1 52	1 46	1 37	1 32	1 29	1 28	1 29	1 30	1 31	1 33	1 35	20
21	3 8	2 43	2 26	2 13	2 3	1 55	1 48	1 39	1 33	1 30	1 28	1 28	1 29	1 30	1 31	1 33	21
22	3 15	2 49	2 32	2 17	2 7	1 58	1 51	1 41	1 35	1 31	1 29	1 27	1 28	1 29	1 30	1 31	22
23	3 23	2 56	2 37	2 22	2 11	2 2	1 54	1 43	1 37	1 32	1 29	1 27	1 27	1 28	1 29	1 30	23
24	3 31	3 3	2 43	2 27	2 15	2 5	1 57	1 46	1 39	1 34	1 30	1 28	1 27	1 28	1 28	1 29	24
25	3 39	3 9	2 48	2 32	2 19	2 9	2 0	1 48	1 41	1 35	1 31	1 29	1 27	1 27	1 27	1 28	25
26	3 47	3 16	2 54	2 37	2 23	2 12	2 4	1 51	1 43	1 36	1 32	1 30	1 28	1 27	1 27	1 27	26
27	3 55	3 23	3 0	2 42	2 27	2 16	2 7	1 54	1 44	1 37	1 33	1 30	1 28	1 27	1 26	1 27	27
28	4 2	3 29	3 5	2 47	2 31	2 19	2 10	1 56	1 46	1 39	1 34	1 31	1 29	1 27	1 26	1 26	28
29	4 10	3 36	3 11	2 52	2 35	2 23	2 14	1 59	1 48	1 41	1 35	1 32	1 29	1 27	1 26	1 26	29
30	4 17	3 42	3 16	2 57	2 40	2 27	2 17	2 1	1 50	1 42	1 36	1 32	1 29	1 27	1 26	1 26	30
31	4 25	3 49	3 22	3 2	2 44	2 31	2 20	2 3	1 52	1 43	1 37	1 33	1 30	1 28	1 27	1 26	31
32	4 32	3 55	3 27	3 7	2 49	2 34	2 23	2 6	1 54	1 45	1 38	1 33	1 30	1 28	1 27	1 26	32
33	4 40	4 2	3 33	3 12	2 53	2 38	2 26	2 9	1 56	1 47	1 39	1 34	1 31	1 29	1 27	1 26	33
34	4 48	4 8	3 39	3 16	2 57	2 42	2 30	2 12	1 58	1 48	1 41	1 35	1 32	1 30	1 28	1 26	34
35	4 55	4 15	3 45	3 21	3 2	2 46	2 34	2 15	2 0	1 50	1 43	1 37	1 33	1 30	1 28	1 26	35
36	5 2	4 21	3 50	3 26	3 6	2 50	2 37	2 17	2 3	1 52	1 44	1 38	1 34	1 31	1 28	1 26	36
37	5 10	4 27	3 56	3 30	3 10	2 53	2 41	2 20	2 5	1 54	1 46	1 39	1 35	1 31	1 28	1 26	37
38	5 17	4 33	4 1	3 35	3 14	2 57	2 44	2 22	2 7	1 56	1 48	1 41	1 36	1 32	1 29	1 27	38
39	5 24	4 39	4 6	3 40	3 18	3 1	2 47	2 25	2 9	1 58	1 50	1 43	1 37	1 33	1 30	1 27	39
40	5 31	4 45	4 11	3 45	3 22	3 5	2 50	2 27	2 11	2 0	1 51	1 44	1 38	1 34	1 31	1 28	40
41	5 38	4 51	4 16	3 49	3 26	3 9	2 53	2 30	2 14	2 2	1 53	1 45	1 39	1 35	1 31	1 28	41
42	5 44	4 57	4 21	3 53	3 30	3 12	2 56	2 32	2 16	2 4	1 54	1 46	1 40	1 36	1 32	1 29	42
43	5 50	5 2	4 26	3 58	3 34	3 16	2 59	2 34	2 19	2 6	1 56	1 48	1 41	1 37	1 33	1 30	43
44	5 57	5 8	4 31	4 2	3 38	3 19	3 3	2 37	2 21	2 8	1 57	1 49	1 43	1 38	1 34	1 31	44
46	6 10	5 19	4 41	4 10	3 46	3 26	3 9	2 42	2 25	2 11	1 59	1 51	1 45	1 40	1 35	1 31	46
48	6 22	5 29	4 50	4 18	3 53	3 32	3 15	2 47	2 29	2 14	2 2	1 54	1 47	1 41	1 36	1 32	48
50	6 34	5 39	4 59	4 26	3 59	3 38	3 21	2 52	2 33	2 18	2 5	1 56	1 49	1 43	1 38	1 33	50
52	6 45	5 48	5 7	4 33	4 6	3 44	3 26	2 56	2 36	2 21	2 8	1 58	1 51	1 45	1 39	1 35	52
54	6 56	5 57	5 14	4 40	4 12	3 50	3 31	3 0	2 39	2 24	2 11	2 0	1 52	1 46	1 40	1 36	54
56	7 6	6 6	5 21	4 46	4 18	3 55	3 36	3 4	2 42	2 27	2 14	2 2	1 54	1 47	1 41	1 37	56
58	7 15	6 14	5 28	4 52	4 24	4 0	3 41	3 8	2 45	2 29	2 16	2 4	1 56	1 49	1 43	1 38	58
60	7 24	6 22	5 35	4 58	4 29	4 5	3 45	3 12	2 48	2 32	2 18	2 6	1 58	1 51	1 45	1 39	60
62	7 33	6 29	5 42	5 3	4 34	4 10	3 49	3 15	2 [illegible]	2 34	2 20	2 8	1 59	1 52	1 46	1 40	62
64	7 41	6 35	5 48	5 8	4 39	4 14	3 53	3 18	2 54	2 36	2 22	2 10	2 1	1 53	1 47	1 41	64
66	7 48	6 41	5 53	5 13	4 43	4 18	3 57	3 21	2 56	2 38	2 24	2 12	2 2	1 54	1 48	1 42	66
58	7 55	6 47	5 58	5 17	4 47	4 22	4 0	3 24	2 59	2 40	2 26	2 14	2 3	1 55	1 49	1 43	68
70	8 1	6 52	6 3	5 21	4 51	4 25	4 3	3 27	3 1	2 42	2 27	2 15	2 4	1 56	1 50	1 44	70
72	8 7	6 57	6 8	5 25	4 55	4 28	4 6	3 30	3 3	2 44	2 28	2 15	2 5	1 57	1 51	1 45	72
74	8 12	7 1	6 12	5 29	4 58	4 30	4 8	3 32	3 5	2 45	2 29	2 16	2 5	1 57	1 51	1 45	74
76	8 17	7 5	6 15	5 32	5 1	4 32	4 10	3 34	3 7	2 46	2 30	2 17	2 6	1 58	1 51	1 45	76
78			6 18	5 35	5 3	4 34	4 12	3 35	3 9	2 47	2 31	2 18	2 7	1 58	1 52	1 46	78
80					5 5	4 36	4 13	3 36	3 10	2 48	2 32	2 18	2 7	1 59	1 52	1 46	80
82							4 14	3 37	3 11	2 49	2 32	2 19	2 8	1 59	1 52	1 46	82
84								3 38	3 11	2 50	2 33	2 20	2 9	2 0	1 53	1 46	84
86									3 12	2 50	2 33	2 20	2 9	2 0	1 53		86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 68°.

☽'s App. Alt.	*Apparent Altitude of the Sun, Star or Planet.* 32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	☽'s App. Alt.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″		°
6	4 25	4 40	4 55	5 11	5 40	6 5	6 29	6 51	7 11	7 29	7 45	8 0	8 14				6
7	3 49	4 1	4 14	4 27	4 52	5 15	5 35	5 53	6 10	6 25	6 38	6 50	7 1				7
8	3 22	3 33	3 44	3 55	4 17	4 37	4 55	5 11	5 25	5 38	5 51	6 2	6 10	6 18			8
9	3 1	3 11	3 21	3 30	3 48	4 6	4 22	4 36	4 49	5 0	5 10	5 19	5 28	5 36			9
10	2 44	2 53	3 2	3 10	3 25	3 41	3 55	4 9	4 21	4 31	4 40	4 49	4 57	5 3			10
11	2 31	2 39	2 47	2 54	3 8	3 22	3 35	3 47	3 58	4 8	4 16	4 23	4 29	4 34			11
12	2 20	2 27	2 34	2 41	2 53	3 6	3 18	3 29	3 39	3 48	3 55	4 2	4 7	4 11	4 15		12
13	2 11	2 17	2 23	2 29	2 41	2 52	3 2	3 12	3 22	3 30	3 37	3 43	3 48	3 52	3 56		13
14	2 3	2 9	2 14	2 19	2 30	2 40	2 49	2 58	3 6	3 14	3 20	3 26	3 31	3 35	3 38		14
15	1 57	2 2	2 6	2 11	2 21	2 30	2 38	2 46	2 54	3 1	3 7	3 12	3 16	3 20	3 23		15
16	1 52	1 56	2 0	2 4	2 13	2 21	2 29	2 37	2 44	2 50	2 55	3 0	3 4	3 8	3 10	3 12	16
17	1 47	1 51	1 55	1 58	2 6	2 14	2 21	2 29	2 35	2 40	2 45	2 49	2 53	2 57	2 59	3 0	17
18	1 43	1 47	1 50	1 54	2 1	2 8	2 14	2 21	2 27	2 32	2 36	2 40	2 44	2 47	2 49	2 50	18
19	1 40	1 43	1 46	1 50	1 56	2 2	2 8	2 15	2 20	2 25	2 29	2 32	2 36	2 39	2 41	2 42	19
20	1 37	1 40	1 43	1 46	1 52	1 57	2 3	2 9	2 14	2 18	2 22	2 25	2 28	2 31	2 33	2 34	20
21	1 35	1 37	1 40	1 43	1 48	1 53	1 58	2 3	2 8	2 12	2 16	2 19	2 21	2 23	2 25	2 26	21
22	1 33	1 35	1 37	1 40	1 44	1 49	1 54	1 58	2 2	2 6	2 10	2 13	2 15	2 17	2 19	2 20	22
23	1 31	1 33	1 35	1 37	1 41	1 46	1 50	1 54	1 57	2 1	2 5	2 8	2 10	2 12	2 14	2 15	23
24	1 30	1 31	1 33	1 35	1 39	1 43	1 47	1 50	1 53	1 57	2 0	2 3	2 5	2 7	2 9	2 10	24
25	1 29	1 30	1 31	1 33	1 37	1 40	1 44	1 47	1 50	1 53	1 56	1 59	2 1	2 2	2 4	2 5	25
26	1 28	1 29	1 30	1 32	1 35	1 38	1 41	1 44	1 47	1 50	1 53	1 55	1 57	1 58	1 59	2 0	26
27	1 27	1 28	1 29	1 30	1 33	1 36	1 38	1 41	1 44	1 47	1 50	1 52	1 53	1 54	1 55	1 56	27
28	1 27	1 27	1 28	1 29	1 31	1 34	1 36	1 39	1 41	1 44	1 47	1 49	1 50	1 51	1 52	1 52	28
29	1 26	1 26	1 27	1 28	1 29	1 32	1 34	1 37	1 39	1 41	1 44	1 46	1 47	1 48	1 49		29
30	1 26	1 26	1 26	1 27	1 28	1 30	1 32	1 35	1 37	1 39	1 41	1 43	1 44	1 45	1 46		30
31	1 25	1 25	1 26	1 26	1 27	1 29	1 31	1 33	1 35	1 37	1 39	1 40	1 41	1 42	1 43		31
32	1 25	1 25	1 25	1 25	1 26	1 28	1 29	1 31	1 33	1 35	1 37	1 38	1 39	1 40	1 41		32
33	1 25	1 24	1 25	1 25	1 26	1 27	1 28	1 30	1 31	1 33	1 35	1 36	1 37	1 38			33
34	1 25	1 24	1 24	1 24	1 25	1 26	1 27	1 29	1 30	1 31	1 33	1 34	1 35	1 36			34
35	1 25	1 24	1 24	1 24	1 24	1 25	1 26	1 28	1 29	1 30	1 31	1 32	1 33	1 34			35
36	1 25	1 24	1 23	1 23	1 23	1 24	1 25	1 27	1 28	1 29	1 30	1 30	1 31	1 32			36
37	1 25	1 24	1 23	1 23	1 23	1 23	1 24	1 26	1 27	1 28	1 29	1 29	1 30				37
38	1 25	1 24	1 23	1 22	1 22	1 23	1 24	1 25	1 26	1 27	1 28	1 28	1 29				38
39	1 25	1 24	1 23	1 22	1 22	1 23	1 23	1 24	1 25	1 26	1 27	1 27	1 27				39
40	1 26	1 25	1 24	1 23	1 22	1 22	1 23	1 23	1 24	1 25	1 26	1 26	1 26				40
41	1 26	1 25	1 24	1 23	1 21	1 21	1 22	1 22	1 23	1 24	1 25	1 25					41
42	1 27	1 25	1 24	1 23	1 21	1 21	1 21	1 22	1 23	1 23	1 24	1 24					42
43	1 27	1 25	1 24	1 23	1 21	1 21	1 21	1 21	1 22	1 22	1 23	1 23					43
44	1 28	1 26	1 24	1 23	1 21	1 20	1 20	1 20	1 21	1 21	1 22	1 22					44
46	1 28	1 26	1 25	1 24	1 21	1 19	1 19	1 19	1 20	1 20	1 20						46
48	1 29	1 27	1 25	1 24	1 22	1 19	1 18	1 18	1 19	1 19	1 19						48
50	1 30	1 28	1 26	1 25	1 22	1 20	1 18	1 18	1 18	1 18							50
52	1 31	1 29	1 27	1 25	1 22	1 20	1 18	1 17	1 17	1 17							52
54	1 32	1 29	1 27	1 26	1 23	1 20	1 18	1 17	1 16								54
56	1 33	1 30	1 28	1 26	1 23	1 20	1 18	1 16	1 15								56
58	1 34	1 31	1 29	1 27	1 23	1 20	1 18	1 16									
60	1 35	1 32	1 29	1 27	1 23	1 20	1 18	1 16									
62	1 36	1 33	1 30	1 28	1 23	1 20	1 18										
64	1 37	1 33	1 30	1 28	1 24	1 20	1 17										
66	1 38	1 34	1 31	1 28	1 24	1 20											
68	1 38	1 34	1 31	1 28	1 24	1 20											
70	1 39	1 35	1 32	1 29	1 24												
72	1 39	1 35	1 32	1 29	1 24												
74	1 40	1 36	1 32	1 29													
76	1 40	1 36	1 32	1 29													
78	1 41	1 36	1 32														
80	1 41	1 36															
82	1 41																
84																	
86																	
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°						

Table P. Effect of Sun's Par.

Add the Numbers above the lines to Third Correction; subtract the others.

☽'s App. Alt.	Sun's Apparent Altitude. 5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	1	0	0	1	1	2	2	3		
10	2	1	0	0	1	1	1	2	2	
20	3	3	2	1	1	0	0	0	0	0
30	4	4	4	3	2	2	2	1	1	
40	6	6	5	4	4	3	3	3		
50	7	7	6	6	5	5	4			
60	8	8	7	7	6	6				
70	9	8	8	7	7					
80		9	8							
90		8								

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 72°.

☽'s App. Alt.	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	☽'s App. Alt.
	Apparent Altitude of the Sun, Star or Planet.																
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 33	1 35	1 37	1 40	1 44	1 50	1 56	2 9	2 23	2 38	2 53	3 9	3 24	3 40	3 56	4 12	6
7	1 35	1 33	1 34	1 36	1 39	1 43	1 47	1 56	2 8	2 21	2 34	2 47	3 0	3 12	3 25	3 38	7
8	1 39	1 35	1 33	1 34	1 36	1 38	1 41	1 48	1 58	2 8	2 19	2 30	2 41	2 52	3 3	3 14	8
9	1 44	1 38	1 35	1 33	1 34	1 35	1 37	1 42	1 50	1 58	2 7	2 17	2 26	2 35	2 44	2 54	9
10	1 50	1 42	1 37	1 34	1 33	1 34	1 35	1 38	1 44	1 50	1 58	2 6	2 14	2 22	2 30	2 39	10
11	1 56	1 46	1 40	1 36	1 34	1 33	1 34	1 36	1 40	1 45	1 51	1 58	2 5	2 12	2 20	2 27	11
12	2 2	1 51	1 44	1 39	1 36	1 34	1 33	1 35	1 37	1 41	1 46	1 52	1 58	2 4	2 11	2 17	12
13	2 9	1 56	1 48	1 42	1 39	1 36	1 34	1 34	1 35	1 38	1 42	1 47	1 52	1 58	2 4	2 9	13
14	2 16	2 2	1 53	1 46	1 42	1 39	1 36	1 33	1 34	1 36	1 39	1 43	1 47	1 52	1 57	2 2	14
15	2 23	2 8	1 58	1 50	1 45	1 41	1 38	1 34	1 33	1 34	1 36	1 39	1 43	1 47	1 51	1 56	15
16	2 30	2 14	2 3	1 54	1 48	1 43	1 40	1 35	1 33	1 33	1 34	1 36	1 39	1 43	1 47	1 52	16
17	2 37	2 20	2 8	1 58	1 51	1 46	1 42	1 36	1 34	1 33	1 34	1 35	1 37	1 40	1 44	1 48	17
18	2 45	2 27	2 13	2 2	1 54	1 48	1 44	1 37	1 34	1 33	1 33	1 34	1 36	1 38	1 41	1 44	18
19	2 53	2 33	2 18	2 7	1 58	1 51	1 46	1 39	1 35	1 33	1 33	1 34	1 35	1 37	1 39	1 41	19
20	3 1	2 40	2 24	2 11	2 2	1 54	1 49	1 41	1 36	1 34	1 33	1 33	1 34	1 35	1 37	1 39	20
21	3 9	2 46	2 29	2 16	2 6	1 58	1 52	1 43	1 37	1 34	1 33	1 33	1 33	1 34	1 35	1 37	21
22	3 17	2 53	2 35	2 20	2 10	2 2	1 55	1 45	1 39	1 35	1 33	1 32	1 33	1 33	1 34	1 35	22
23	3 25	2 59	2 40	2 25	2 14	2 5	1 58	1 47	1 40	1 36	1 34	1 32	1 32	1 33	1 33	1 34	23
24	3 33	3 6	2 46	2 30	2 18	2 8	2 1	1 50	1 42	1 37	1 34	1 32	1 32	1 32	1 33	1 34	24
25	3 41	3 12	2 51	2 35	2 23	2 12	2 4	1 52	1 44	1 38	1 35	1 33	1 32	1 32	1 32	1 33	25
26	3 48	3 18	2 57	2 40	2 27	2 16	2 8	1 55	1 46	1 40	1 36	1 33	1 32	1 31	1 31	1 32	26
27	3 56	3 25	3 2	2 45	2 31	2 20	2 12	1 57	1 48	1 41	1 37	1 34	1 32	1 31	1 31	1 31	27
28	4 3	3 31	3 7	2 49	2 35	2 24	2 15	2 0	1 50	1 43	1 38	1 34	1 32	1 31	1 30	1 31	28
29	4 11	3 37	3 13	2 54	2 39	2 27	2 18	2 2	1 52	1 45	1 39	1 35	1 33	1 32	1 31	1 30	29
30	4 18	3 44	3 19	2 59	2 43	2 31	2 21	2 5	1 54	1 46	1 40	1 36	1 34	1 32	1 31	1 30	30
31	4 26	3 50	3 24	3 4	2 47	2 34	2 24	2 8	1 56	1 48	1 41	1 37	1 34	1 32	1 31	1 30	31
32	4 33	3 56	3 29	3 9	2 51	2 38	2 27	2 11	1 58	1 50	1 43	1 38	1 35	1 33	1 32	1 31	32
33	4 40	4 2	3 35	3 14	2 56	2 42	2 30	2 14	2 0	1 51	1 44	1 39	1 35	1 33	1 32	1 31	33
34	4 47	4 9	3 41	3 18	3 0	2 45	2 33	2 16	2 2	1 53	1 46	1 40	1 36	1 34	1 32	1 31	34
35	4 54	4 15	3 46	3 23	3 4	2 49	2 37	2 18	2 4	1 54	1 47	1 41	1 37	1 34	1 32	1 31	35
36	5 1	4 21	3 51	3 27	3 8	2 53	2 40	2 20	2 7	1 56	1 48	1 42	1 38	1 35	1 33	1 32	36
37	5 9	4 27	3 56	3 32	3 12	2 57	2 43	2 23	2 9	1 58	1 50	1 44	1 39	1 36	1 33	1 32	37
38	5 16	4 33	4 1	3 37	3 16	3 0	2 47	2 26	2 11	2 0	1 52	1 45	1 40	1 37	1 34	1 32	38
39	5 23	4 39	4 6	3 41	3 20	3 4	2 50	2 28	2 13	2 2	1 53	1 46	1 41	1 38	1 34	1 32	39
40	5 30	4 45	4 11	3 46	3 24	3 7	2 54	2 30	2 15	2 4	1 54	1 48	1 43	1 39	1 35	1 33	40
41	5 37	4 51	4 16	3 50	3 28	3 11	2 57	2 32	2 18	2 6	1 56	1 49	1 44	1 40	1 36	1 33	41
42	5 44	4 57	4 21	3 54	3 32	3 15	3 0	2 35	2 20	2 8	1 58	1 50	1 45	1 41	1 37	1 34	42
43	5 51	5 2	4 26	3 59	3 36	3 18	3 3	2 37	2 22	2 10	1 59	1 51	1 46	1 42	1 38	1 34	43
44	5 57	5 7	4 30	4 3	3 40	3 22	3 6	2 41	2 24	2 12	2 1	1 53	1 47	1 43	1 39	1 35	44
46	6 9	5 17	4 39	4 11	3 47	3 29	3 12	2 45	2 28	2 15	2 4	1 55	1 49	1 44	1 40	1 36	46
48	6 21	5 27	4 48	4 19	3 54	3 35	3 18	2 50	2 32	2 18	2 7	1 58	1 51	1 45	1 41	1 38	48
50	6 32	5 37	4 57	4 26	4 1	3 41	3 23	2 55	2 35	2 21	2 10	2 0	1 53	1 47	1 43	1 39	50
52	6 43	5 46	5 6	4 33	4 7	3 46	3 28	2 59	2 39	2 24	2 12	2 2	1 55	1 49	1 44	1 40	52
54	6 54	5 55	5 14	4 40	4 13	3 52	3 33	3 3	2 43	2 27	2 15	2 5	1 57	1 50	1 45	1 41	54
56	7 4	6 4	5 22	4 47	4 19	3 57	3 38	3 7	2 47	2 31	2 18	2 7	1 59	1 52	1 46	1 42	56
58	7 13	6 12	5 29	4 53	4 25	4 2	3 43	3 11	2 50	2 34	2 21	2 9	2 0	1 53	1 47	1 43	58
60	7 22	6 20	5 35	4 58	4 30	4 7	3 47	3 15	2 53	2 37	2 23	2 11	2 2	1 54	1 49	1 44	60
62	7 31	6 27	5 41	5 3	4 35	4 11	3 51	3 19	2 56	2 39	2 25	2 13	2 4	1 56	1 50	1 45	62
64	7 39	6 33	5 47	5 8	4 40	4 15	3 55	3 22	2 59	2 41	2 27	2 15	2 5	1 57	1 51	1 46	64
66	7 46	6 39	5 53	5 13	4 44	4 19	3 59	3 25	3 1	2 43	2 29	2 16	2 6	1 58	1 52	1 47	66
68	7 52	6 45	5 58	5 18	4 48	4 23	4 2	3 28	3 3	2 45	2 30	2 18	2 7	1 59	1 52	1 47	68
70	7 58	6 50	6 3	5 22	4 52	4 26	4 4	3 30	3 5	2 47	2 31	2 19	2 8	2 0	1 53	1 48	70
72	8 4	6 55	6 7	5 26	4 55	4 29	4 7	3 32	3 7	2 48	2 33	2 20	2 9	2 1	1 54	1 48	72
74	8 9	7 0	6 10	5 30	4 58	4 31	4 9	3 34	3 9	2 49	2 34	2 21	2 10	2 2	1 55	1 49	74
76	8 13	7 4	6 14	5 33	5 1	4 33	4 11	3 35	3 11	2 50	2 35	2 22	2 11	2 2	1 56	1 49	76
78	8 16	7 7	6 17	5 36	5 3	4 35	4 12	3 37	3 12	2 51	2 36	2 23	2 12	2 3	1 56	1 50	78
80	8 19	7 10	6 19	5 38	5 5	4 37	4 14	3 38	3 13	2 52	2 37	2 24	2 13	2 4	1 57	1 51	80
82			6 21	5 40	5 7	4 39	4 16	3 39	3 13	2 53	2 38	2 24	2 13	2 4	1 57		82
84					5 9	4 41	4 17	3 40	3 14	2 54	2 38	2 24	2 14	2 5			84
86							4 ·8	3 41	3 15	2 54	2 38	2 24	2 14				86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 72°.

☽'s App. Alt.	*Apparent Altitude of the Sun, Star or Planet.*																☽'s App. Alt.
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	4 27	4 41	4 56	5 11	5 36	6 3	6 27	6 48	7 8	7 27	7 42	7 55	8 6	8 16			6
7	3 51	4 3	4 16	4 28	4 51	5 12	5 32	5 51	6 8	6 23	6 36	6 48	6 58	7 7			7
8	3 25	3 36	3 47	3 58	4 18	4 36	4 54	5 11	5 26	5 39	5 51	6 1	6 9	6 16	6 22		8
9	3 4	3 14	3 24	3 33	3 51	4 8	4 23	4 37	4 50	5 1	5 11	5 20	5 28	5 35	5 41		9
10	2 48	2 57	3 6	3 14	3 29	3 44	3 58	4 10	4 22	4 33	4 42	4 50	4 57	5 3	5 7		10
11	2 35	2 43	2 51	2 58	3 11	3 25	3 37	3 48	3 59	4 9	4 17	4 24	4 30	4 35	4 39		11
12	2 24	2 31	2 38	2 45	2 57	3 9	3 20	3 31	3 41	3 49	3 57	4 3	4 8	4 12	4 16	4 20	12
13	2 15	2 21	2 27	2 33	2 45	2 56	3 6	3 16	3 24	3 32	3 39	3 45	3 49	3 53	3 56	3 59	13
14	2 7	2 13	2 18	2 24	2 34	2 44	2 54	3 2	3 10	3 18	3 24	3 29	3 33	3 36	3 39	3 41	14
15	2 1	2 6	2 11	2 16	2 25	2 34	2 43	2 51	2 58	3 5	3 11	3 16	3 20	3 23	3 25	3 27	15
16	1 56	2 1	2 5	2 9	2 18	2 26	2 33	2 41	2 48	2 54	2 59	3 4	3 8	3 11	3 13	3 15	16
17	1 52	1 56	1 59	2 3	2 11	2 19	2 25	2 32	2 39	2 45	2 50	2 54	2 57	3 0	3 2	3 4	17
18	1 48	1 51	1 54	1 58	2 6	2 13	2 19	2 25	2 31	2 37	2 42	2 46	2 48	2 50	2 52	2 54	18
19	1 44	1 47	1 50	1 54	2 1	2 7	2 13	2 19	2 25	2 30	2 35	2 38	2 40	2 42	2 44	2 45	19
20	1 41	1 44	1 47	1 50	1 56	2 2	2 7	2 13	2 19	2 23	2 28	2 31	2 33	2 35	2 36	2 37	20
21	1 39	1 41	1 44	1 46	1 52	1 57	2 2	2 8	2 13	2 17	2 21	2 24	2 26	2 28	2 29	2 30	21
22	1 37	1 39	1 41	1 43	1 48	1 53	1 58	2 3	2 7	2 11	2 15	2 18	2 20	2 22	2 23	2 24	22
23	1 36	1 37	1 39	1 41	1 45	1 50	1 54	1 59	2 2	2 6	2 10	2 13	2 15	2 16	2 17	2 18	23
24	1 35	1 36	1 37	1 39	1 43	1 47	1 51	1 55	1 58	2 2	2 5	2 8	2 10	2 11	2 12	2 13	24
25	1 34	1 35	1 36	1 38	1 41	1 44	1 48	1 51	1 54	1 58	2 1	2 3	2 5	2 6	2 8		25
26	1 33	1 34	1 35	1 36	1 39	1 42	1 45	1 48	1 51	1 54	1 57	1 59	2 1	2 2	2 4		26
27	1 32	1 33	1 34	1 35	1 37	1 40	1 43	1 45	1 48	1 51	1 54	1 56	1 57	1 58	2 0		27
28	1 32	1 32	1 33	1 34	1 35	1 38	1 41	1 43	1 46	1 48	1 51	1 53	1 54	1 55	1 56		28
29	1 31	1 32	1 32	1 33	1 34	1 36	1 39	1 41	1 44	1 46	1 48	1 50	1 52	1 53			29
30	1 31	1 31	1 32	1 32	1 33	1 35	1 37	1 39	1 42	1 44	1 46	1 47	1 49	1 50			30
31	1 30	1 31	1 31	1 31	1 32	1 34	1 36	1 38	1 40	1 42	1 44	1 45	1 46	1 47			31
32	1 29	1 30	1 30	1 30	1 31	1 33	1 35	1 36	1 38	1 40	1 42	1 43	1 44	1 45			32
33	1 29	1 29	1 29	1 30	1 31	1 32	1 33	1 34	1 36	1 38	1 40	1 41	1 42				33
34	1 30	1 29	1 29	1 29	1 30	1 31	1 32	1 33	1 34	1 36	1 38	1 39	1 40				34
35	1 30	1 29	1 29	1 29	1 30	1 30	1 31	1 32	1 33	1 35	1 36	1 37	1 38				35
36	1 31	1 29	1 28	1 28	1 29	1 30	1 31	1 32	1 33	1 34	1 35	1 36	1 36				36
37	1 31	1 30	1 28	1 28	1 29	1 29	1 30	1 31	1 32	1 33	1 34	1 35					37
38	1 31	1 30	1 28	1 27	1 28	1 29	1 30	1 31	1 32	1 33	1 33	1 34					38
39	1 31	1 30	1 29	1 28	1 28	1 28	1 29	1 30	1 31	1 32	1 32	1 32					39
40	1 31	1 30	1 29	1 28	1 27	1 28	1 28	1 29	1 30	1 30	1 30	1 30					40
41	1 31	1 30	1 29	1 28	1 27	1 27	1 27	1 28	1 28	1 29	1 29						41
42	1 32	1 31	1 29	1 28	1 26	1 26	1 26	1 27	1 27	1 28	1 28						42
43	1 32	1 31	1 29	1 28	1 26	1 26	1 26	1 26	1 26	1 27	1 27						43
44	1 33	1 31	1 30	1 28	1 26	1 26	1 25	1 25	1 25	1 26	1 26						44
46	1 34	1 32	1 30	1 29	1 27	1 25	1 25	1 25	1 25	1 25							46
48	1 35	1 32	1 30	1 29	1 27	1 25	1 24	1 24	1 24	1 24							48
50	1 36	1 33	1 31	1 30	1 27	1 25	1 24	1 23	1 23								50
52	1 37	1 34	1 31	1 30	1 27	1 25	1 23	1 22	1 23								52
54	1 37	1 34	1 32	1 31	1 28	1 25	1 23	1 22									54
56	1 38	1 35	1 33	1 31	1 28	1 25	1 23	1 22									56
58	1 39	1 36	1 34	1 32	1 28	1 25	1 23										58
60	1 39	1 36	1 34	1 32	1 28	1 25	1 23										60
62	1 40	1 37	1 35	1 32	1 28	1 25											62
64	1 41	1 38	1 36	1 33	1 28	1 25											64
66	1 42	1 38	1 36	1 33	1 28												66
68	1 43	1 39	1 36	1 34	1 29												68
70	1 43	1 39	1 36	1 34													70
72	1 44	1 40	1 36	1 34													72
74	1 44	1 40	1 36														74
76	1 45	1 40															76
78	1 45																78
80																	80
82																	82
84																	84
86																	86
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°						

Table P. Effect of Sun's Par.

Add the Numbers above the lines to Third Correction; subtract the others.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	1	0	0	1	1	2	2	2		
10	2	1	1	0	0	1	1	1	1	
20	3	3	2	2	1	1	1	1	0	0
30	4	4	4	3	3	2	2	2	2	
40	6	6	5	5	4	4	4	3		
50	7	7	6	6	5	5	5			
60	8	8	7	7	6	6				
70	9	8	8	7	7					
80		9	8	8						
90			9							

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 76°.

☽'s App. Alt.	*Apparent Altitude of the Sun, Star or Planet.*																☽'s App. Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ′	°
6	1 37	1 39	1 41	1 44	1 48	1 54	2 0	2 13	2 27	2 42	2 57	3 13	3 28	3 43	3 58	4 13	6
7	1 40	1 37	1 38	1 40	1 43	1 47	1 51	2 1	2 12	2 24	2 37	2 50	3 3	3 15	3 28	3 40	7
8	1 44	1 40	1 37	1 38	1 40	1 42	1 45	1 52	2 2	2 12	2 22	2 33	2 44	2 54	3 5	3 16	8
9	1 49	1 43	1 39	1 37	1 38	1 39	1 41	1 46	1 54	2 2	2 11	2 20	2 30	2 39	2 48	2 58	9
10	1 54	1 46	1 41	1 39	1 37	1 38	1 39	1 42	1 48	1 55	2 2	2 10	2 18	2 26	2 34	2 43	10
11	2 0	1 50	1 44	1 41	1 39	1 37	1 38	1 40	1 44	1 49	1 55	2 2	2 9	2 16	2 23	2 31	11
12	2 6	1 55	1 48	1 44	1 41	1 38	1 37	1 38	1 41	1 45	1 50	1 56	2 2	2 8	2 15	2 21	12
13	2 12	2 0	1 52	1 47	1 43	1 40	1 38	1 37	1 39	1 42	1 46	1 51	1 56	2 2	2 8	2 13	13
14	2 19	2 6	1 56	1 50	1 45	1 42	1 40	1 37	1 38	1 40	1 43	1 47	1 52	1 57	2 2	2 7	14
15	2 26	2 12	2 1	1 54	1 48	1 44	1 42	1 38	1 37	1 39	1 41	1 45	1 49	1 53	1 57	2 1	15
16	2 34	2 18	2 6	1 58	1 51	1 47	1 44	1 39	1 37	1 38	1 40	1 43	1 46	1 49	1 53	1 56	16
17	2 41	2 24	2 11	2 2	1 54	1 49	1 46	1 40	1 38	1 37	1 39	1 41	1 43	1 46	1 49	1 52	17
18	2 49	2 30	2 17	2 6	1 58	1 52	1 48	1 42	1 39	1 36	1 38	1 39	1 41	1 43	1 46	1 49	18
19	2 57	2 36	2 22	2 10	2 2	1 55	1 50	1 43	1 40	1 37	1 37	1 38	1 39	1 41	1 43	1 46	19
20	3 5	2 43	2 27	2 15	2 6	1 58	1 52	1 45	1 41	1 38	1 36	1 37	1 38	1 39	1 41	1 43	20
21	3 12	2 49	2 33	2 20	2 10	2 2	1 55	1 47	1 42	1 39	1 37	1 36	1 37	1 38	1 39	1 41	21
22	3 20	2 56	2 38	2 24	2 14	2 5	1 58	1 49	1 44	1 40	1 38	1 36	1 36	1 37	1 38	1 39	22
23	3 28	3 3	2 44	2 29	2 18	2 9	2 1	1 51	1 45	1 41	1 38	1 36	1 35	1 36	1 37	1 38	23
24	3 36	3 9	2 49	2 34	2 22	2 12	2 4	1 54	1 47	1 42	1 39	1 37	1 35	1 36	1 36	1 37	24
25	3 44	3 15	2 54	2 39	2 26	2 16	2 7	1 56	1 49	1 44	1 40	1 37	1 36	1 36	1 36	1 37	25
26	3 51	3 21	3 0	2 44	2 30	2 20	2 11	1 59	1 51	1 45	1 41	1 38	1 36	1 35	1 35	1 36	26
27	3 59	3 28	3 5	2 49	2 34	2 23	2 14	2 2	1 53	1 47	1 42	1 39	1 37	1 36	1 35	1 35	27
28	4 6	3 34	3 10	2 54	2 38	2 27	2 17	2 4	1 54	1 48	1 43	1 39	1 37	1 36	1 35	1 35	28
29	4 13	3 40	3 15	2 58	2 42	2 31	2 21	2 7	1 56	1 49	1 44	1 40	1 38	1 36	1 35	1 34	29
30	4 20	3 46	3 21	3 3	2 47	2 34	2 24	2 9	1 58	1 51	1 45	1 41	1 39	1 37	1 35	1 34	30
31	4 27	3 52	3 26	3 7	2 51	2 38	2 28	2 12	2 0	1 52	1 46	1 42	1 39	1 37	1 35	1 34	31
32	4 34	3 58	3 31	3 12	2 55	2 42	2 31	2 14	2 2	1 54	1 48	1 43	1 40	1 38	1 36	1 35	32
33	4 41	4 4	3 37	3 16	2 59	2 45	2 34	2 17	2 4	1 55	1 49	1 44	1 41	1 38	1 36	1 35	33
34	4 48	4 10	3 42	3 20	3 3	2 49	2 37	2 19	2 6	1 57	1 50	1 45	1 42	1 39	1 37	1 35	34
35	4 55	4 16	3 47	3 25	3 7	2 52	2 41	2 22	2 8	1 59	1 52	1 46	1 42	1 39	1 37	1 35	35
36	5 2	4 22	3 53	3 29	3 11	2 56	2 44	2 24	2 11	2 1	1 53	1 47	1 43	1 40	1 38	1 36	36
37	5 9	4 27	3 58	3 34	3 15	3 0	2 47	2 27	2 13	2 3	1 55	1 48	1 44	1 41	1 38	1 36	37
38	5 16	4 33	4 3	3 38	3 19	3 3	2 50	2 29	2 15	2 4	1 56	1 49	1 45	1 42	1 39	1 37	38
39	5 23	4 38	4 8	3 43	3 23	3 7	2 53	2 31	2 17	2 6	1 58	1 51	1 46	1 42	1 39	1 37	39
40	5 30	4 44	4 13	3 47	3 27	3 10	2 56	2 34	2 19	2 8	1 59	1 52	1 47	1 43	1 40	1 38	40
41	5 37	4 50	4 18	3 51	3 31	3 14	2 59	2 36	2 22	2 10	2 0	1 53	1 48	1 44	1 41	1 38	41
42	5 43	4 55	4 23	3 55	3 34	3 17	3 2	2 39	2 24	2 12	2 1	1 54	1 49	1 45	1 42	1 39	42
43	5 49	5 1	4 28	3 59	3 38	3 20	3 5	2 41	2 26	2 14	2 3	1 56	1 50	1 46	1 43	1 40	43
44	5 55	5 6	4 33	4 3	3 41	3 24	3 8	2 44	2 28	2 15	2 4	1 57	1 51	1 47	1 43	1 40	44
46	6 7	5 16	4 42	4 11	3 49	3 31	3 14	2 49	2 32	2 18	2 7	1 59	1 53	1 48	1 44	1 41	46
48	6 19	5 26	4 51	4 19	3 56	3 37	3 20	2 54	2 35	2 21	2 10	2 2	1 55	1 50	1 46	1 43	48
50	6 30	5 36	4 59	4 27	4 3	3 43	3 25	2 58	2 39	2 25	2 13	2 4	1 57	1 51	1 47	1 44	50
52	6 41	5 46	5 7	4 34	4 10	3 49	3 30	3 3	2 43	2 28	2 16	2 6	1 59	1 53	1 49	1 45	52
54	6 51	5 55	5 15	4 41	4 17	3 55	3 35	3 7	2 47	2 31	2 19	2 9	2 1	1 55	1 50	1 46	54
56	7 1	6 4	5 22	4 48	4 23	4 0	3 40	3 11	2 50	2 34	2 22	2 12	2 3	1 56	1 51	1 47	56
58	7 11	6 12	5 29	4 54	4 28	4 5	3 45	3 15	2 53	2 37	2 25	2 14	2 5	1 57	1 52	1 48	58
60	7 20	6 20	5 36	5 0	4 33	4 9	3 49	3 19	2 56	2 40	2 27	2 16	2 6	1 59	1 53	1 49	60
62	7 28	6 27	5 42	5 5	4 37	4 14	3 53	3 22	2 59	2 43	2 29	2 18	2 8	2 0	1 54	1 50	62
64	7 36	6 34	5 48	5 10	4 41	4 18	3 57	3 25	3 2	2 45	2 31	2 20	2 10	2 2	1 56	1 51	64
66	7 43	6 40	5 54	5 15	4 45	4 22	4 1	3 28	3 5	2 47	2 33	2 21	2 11	2 3	1 57	1 52	66
68	7 49	6 45	5 59	5 19	4 49	4 26	4 5	3 31	3 8	2 49	2 35	2 23	2 13	2 4	1 58	1 53	68
70	7 55	6 50	6 3	5 23	4 53	4 29	4 8	3 34	3 10	2 51	2 36	2 24	2 14	2 5	1 58	1 53	70
72	8 1	6 54	6 7	5 27	4 57	4 32	4 11	3 37	3 12	2 52	2 37	2 25	2 15	2 6	1 59	1 54	72
74	8 6	6 58	6 10	5 30	5 0	4 34	4 13	3 39	3 13	2 53	2 38	2 26	2 16	2 7	2 0	1 54	74
76	8 11	7 2	6 13	5 33	5 3	4 36	4 15	3 41	3 14	2 54	2 39	2 26	2 16	2 7	2 1	1 55	76
78	8 15	7 6	6 16	5 36	5 5	4 38	4 17	3 4[illegible]	3 15	2 55	2 40	2 27	2 17	2 8	2 1		78
80	8 18	7 9	6 19	5 38	5 7	4 40	4 19	3 43	3 16	2 56	2 40	2 28	2 18	2 9			80
82	8 20	7 11	6 21	5 40	5 9	4 42	4 20	3 44	3 17	2 57	2 41	2 28	2 18				82
84	8 22	7 13	6 23	5 42	5 10	4 43	4 21	3 45	3 18	2 58	2 41	2 28					84
86			6 25	5 44	5 11	4 44	4 22	3 45	3 18	2 58	2 42						86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 76°.

☽'s App. Alt.	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	☽'s App. Alt.
°	′ ″	′ ″	′ ″	″	′ ″	′ ″	′ ″	′ ″	′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	4 28	4 42	4 57	5 11	5 37	6 2	6 26	6 47	7 6	7 24	7 40	7 54	8 5	8 13	8 20		6
7	3 53	4 5	4 17	4 29	4 52	5 13	5 33	5 52	6 9	6 24	6 37	6 48	6 57	7 5	7 12		7
8	3 27	3 38	3 49	3 59	4 19	4 38	4 56	5 12	5 26	5 39	5 51	6 1	6 9	6 16	6 21	6 26	8
9	3 8	3 17	3 26	3 35	3 52	4 8	4 24	4 38	4 51	5 3	5 13	5 22	5 29	5 35	5 40	5 44	9
10	2 52	3 0	3 8	3 16	3 31	3 46	4 1	4 14	4 25	4 35	4 44	4 52	4 59	5 4	5 8	5 11	10
11	2 39	2 46	2 53	3 0	3 14	3 27	3 40	3 51	4 2	4 12	4 20	4 27	4 33	4 38	4 42	4 45	11
12	2 28	2 34	2 41	2 47	3 0	3 12	3 23	3 34	3 43	3 52	4 0	4 6	4 11	4 15	4 19	4 22	12
13	2 19	2 25	2 30	2 36	2 48	2 59	3 9	3 19	3 28	3 36	3 43	3 48	3 53	3 57	4 0	4 2	13
14	2 12	2 17	2 22	2 27	2 38	2 48	2 58	3 6	3 14	3 22	3 28	3 33	3 37	3 41	3 43	3 45	14
15	2 5	2 10	2 15	2 19	2 29	2 38	2 47	2 55	3 3	3 9	3 15	3 20	3 24	3 27	3 29	3 31	15
16	2 0	2 4	2 9	2 13	2 21	2 29	2 37	2 45	2 52	2 58	3 4	3 8	3 12	3 15	3 17	3 19	16
17	1 56	1 59	2 3	2 7	2 14	2 22	2 29	2 36	2 43	2 49	2 54	2 58	3 2	3 4	3 6	3 8	17
18	1 52	1 55	1 58	2 2	2 9	2 16	2 23	2 30	2 36	2 42	2 46	2 50	2 53	2 55	2 57	2 58	18
19	1 49	1 51	1 54	1 58	2 4	2 11	2 17	2 24	2 30	2 35	2 39	2 42	2 45	2 47	2 49	2 50	19
20	1 46	1 48	1 51	1 54	2 0	2 6	2 12	2 18	2 24	2 28	2 32	2 35	2 37	2 39	2 41	2 42	20
21	1 43	1 45	1 48	1 51	1 56	2 2	2 7	2 13	2 18	2 22	2 26	2 29	2 31	2 33	2 34		21
22	1 41	1 43	1 46	1 48	1 53	1 58	2 3	2 8	2 13	2 17	2 20	2 23	2 25	2 27	2 28		22
23	1 40	1 42	1 44	1 46	1 50	1 55	1 59	2 3	2 8	2 12	2 15	2 17	2 19	2 21	2 23		23
24	1 39	1 40	1 42	1 44	1 48	1 52	1 56	1 59	2 4	2 7	2 10	2 12	2 14	2 16	2 18		24
25	1 38	1 39	1 40	1 42	1 46	1 49	1 53	1 56	2 0	2 3	2 6	2 8	2 10	2 12			25
26	1 37	1 38	1 39	1 41	1 44	1 47	1 50	1 53	1 56	1 59	2 2	2 4	2 6	2 8			26
27	1 36	1 37	1 38	1 40	1 42	1 45	1 48	1 50	1 53	1 56	1 59	2 1	2 3	2 5			27
28	1 36	1 37	1 38	1 39	1 41	1 43	1 46	1 48	1 50	1 53	1 56	1 58	2 0	2 2			28
29	1 35	1 36	1 37	1 38	1 40	1 42	1 44	1 46	1 48	1 50	1 53	1 55	1 57				29
30	1 35	1 35	1 36	1 37	1 38	1 40	1 42	1 44	1 46	1 48	1 50	1 52	1 54				30
31	1 34	1 34	1 35	1 36	1 37	1 39	1 40	1 42	1 44	1 46	1 48	1 50	1 52				31
32	1 34	1 34	1 34	1 35	1 36	1 38	1 39	1 41	1 43	1 44	1 46	1 48	1 50				32
33	1 34	1 33	1 34	1 35	1 35	1 37	1 38	1 40	1 42	1 43	1 45	1 46					33
34	1 34	1 33	1 33	1 34	1 35	1 36	1 37	1 39	1 41	1 42	1 44	1 45					34
35	1 34	1 33	1 33	1 33	1 34	1 35	1 36	1 38	1 39	1 40	1 42	1 43					35
36	1 35	1 34	1 33	1 33	1 33	1 34	1 35	1 37	1 38	1 39	1 40	1 41					36
37	1 35	1 34	1 33	1 32	1 33	1 33	1 34	1 36	1 37	1 38	1 39						37
38	1 35	1 34	1 33	1 32	1 32	1 33	1 34	1 35	1 36	1 37	1 38						38
39	1 36	1 34	1 33	1 32	1 32	1 33	1 33	1 34	1 35	1 36	1 36						39
40	1 36	1 35	1 34	1 33	1 32	1 32	1 33	1 34	1 34	1 35	1 35						40
41	1 37	1 35	1 34	1 33	1 32	1 32	1 32	1 33	1 33	1 34							41
42	1 37	1 35	1 34	1 33	1 31	1 31	1 32	1 32	1 33	1 33							42
43	1 37	1 35	1 34	1 33	1 31	1 30	1 31	1 31	1 32	1 32							43
44	1 38	1 36	1 34	1 33	1 31	1 30	1 30	1 31	1 31	1 31							44
46	1 39	1 37	1 35	1 34	1 31	1 29	1 29	1 30	1 30								46
48	1 40	1 38	1 36	1 34	1 31	1 29	1 29	1 29	1 29								48
50	1 41	1 38	1 37	1 35	1 32	1 30	1 29	1 29									50
52	1 42	1 39	1 37	1 35	1 32	1 30	1 29	1 26									
54	1 43	1 40	1 38	1 36	1 33	1 30	1 29										
56	1 44	1 41	1 38	1 36	1 33	1 30	1 29										
58	1 45	1 42	1 39	1 37	1 33	1 30											
60	1 46	1 43	1 40	1 37	1 33	1 30											
62	1 46	1 43	1 40	1 37	1 33												
64	1 47	1 44	1 41	1 38	1 33												
66	1 48	1 44	1 41	1 38													
68	1 49	1 45	1 41	1 38													
70	1 49	1 45	1 41														
72	1 49	1 45															
74	1 50																
76																	
78																	
80																	
82																	
84																	
86																	
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°						

Table P. Effect of Sun's Par.

Add the Numbers above the lines to Third Correction; subtract the others.

☽'s App. Alt.	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	1	1	0	0	1	1	1	1	1	
10	1	1	1	0	0	0	0	0	1	
15	2	2	2	1	1	0	0	0	0	0
20	3	3	2	2	2	1	1	1	1	
25	4	4	3	3	2	2	2	2	2	
30	4	4	4	3	3	3	3	3		
35	5	5	4	4	4	4	3	3		
40	6	6	5	5	4	4	4			
45	6	6	6	5	5	5	5			
50	7	7	6	6	6	5				
55	7	7	7	6	6	6				
60	8	8	7	7	7					
65	8	8	8	7	7					
70	8	8	8	8						
75	9	9	8	8						
80	9	9	8							
90		9	8							

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 80°.

☽'s App. Alt.	*Apparent Altitude of the Sun, Star or Planet.*																☽'s App. Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 41	1 43	1 46	1 50	1 54	1 59	2 4	2 17	2 32	2 47	3 2	3 17	3 32	3 47	4 2	4 16	6
7	1 44	1 41	1 43	1 45	1 48	1 51	1 55	2 5	2 17	2 29	2 41	2 54	3 6	3 19	3 31	3 44	7
8	1 48	1 43	1 41	1 42	1 44	1 46	1 49	1 56	2 6	2 16	2 26	2 37	2 48	2 59	3 10	3 20	8
9	1 52	1 46	1 43	1 41	1 42	1 44	1 46	1 51	1 58	2 6	2 15	2 25	2 34	2 43	2 52	3 1	9
10	1 57	1 50	1 46	1 43	1 41	1 42	1 44	1 47	1 53	1 59	2 6	2 14	2 22	2 30	2 38	2 45	10
11	2 3	1 54	1 49	1 45	1 43	1 41	1 42	1 45	1 49	1 54	1 59	2 6	2 13	2 20	2 27	2 34	11
12	2 9	1 59	1 52	1 48	1 45	1 43	1 41	1 43	1 46	1 50	1 54	2 0	2 6	2 12	2 19	2 25	12
13	2 16	2 4	1 56	1 51	1 48	1 45	1 42	1 42	1 44	1 47	1 51	1 56	2 1	2 6	2 12	2 18	13
14	2 23	2 10	2 0	1 54	1 50	1 47	1 44	1 41	1 43	1 45	1 48	1 52	1 57	2 2	2 7	2 12	14
15	2 30	2 16	2 5	1 58	1 53	1 49	1 46	1 42	1 42	1 44	1 46	1 49	1 53	1 58	2 2	2 7	15
16	2 37	2 22	2 10	2 2	1 56	1 52	1 48	1 43	1 41	1 43	1 45	1 47	1 50	1 54	1 58	2 2	16
17	2 45	2 28	2 15	2 6	1 59	1 54	1 50	1 45	1 42	1 42	1 43	1 45	1 48	1 51	1 54	1 58	17
18	2 53	2 34	2 21	2 11	2 3	1 57	1 52	1 47	1 43	1 41	1 42	1 44	1 46	1 48	1 51	1 54	18
19	3 0	2 41	2 26	2 15	2 7	2 0	1 54	1 48	1 44	1 42	1 41	1 43	1 44	1 46	1 49	1 51	19
20	3 8	2 47	2 31	2 20	2 10	2 3	1 57	1 50	1 46	1 43	1 41	1 42	1 43	1 45	1 47	1 49	20
21	3 16	2 54	2 37	2 24	2 14	2 6	1 59	1 52	1 47	1 44	1 42	1 41	1 42	1 43	1 45	1 47	21
22	3 23	3 0	2 43	2 29	2 18	2 9	2 2	1 54	1 49	1 45	1 42	1 40	1 41	1 42	1 43	1 45	22
23	3 31	3 6	2 47	2 33	2 22	2 13	2 5	1 57	1 51	1 47	1 43	1 41	1 40	1 41	1 42	1 44	23
24	3 38	3 12	2 53	2 38	2 25	2 16	2 8	1 59	1 52	1 48	1 44	1 41	1 40	1 41	1 42	1 43	24
25	3 46	3 18	2 58	2 42	2 29	2 19	2 12	2 1	1 54	1 49	1 45	1 42	1 40	1 40	1 41	1 42	25
26	3 53	3 24	3 4	2 47	2 33	2 23	2 15	2 3	1 55	1 50	1 46	1 43	1 41	1 40	1 41	1 42	26
27	4 1	3 31	3 10	2 52	2 37	2 26	2 19	2 6	1 57	1 51	1 47	1 43	1 41	1 40	1 40	1 41	27
28	4 8	3 37	3 15	2 56	2 41	2 30	2 22	2 8	1 59	1 53	1 48	1 44	1 42	1 41	1 40	1 40	28
29	4 15	3 43	3 20	3 1	2 46	2 34	2 26	2 11	2 1	1 55	1 49	1 45	1 43	1 41	1 40	1 39	29
30	4 22	3 49	3 25	3 5	2 50	2 38	2 29	2 14	2 3	1 56	1 50	1 46	1 44	1 42	1 40	1 39	30
31	4 29	3 55	3 30	3 10	2 54	2 41	2 32	2 17	2 5	1 58	1 52	1 47	1 44	1 42	1 40	1 39	31
32	4 36	4 1	3 35	3 14	2 58	2 45	2 35	2 19	2 7	1 59	1 53	1 48	1 45	1 43	1 41	1 39	32
33	4 43	4 7	3 40	3 19	3 2	2 49	2 38	2 22	2 9	2 1	1 54	1 49	1 46	1 44	1 42	1 40	33
34	4 50	4 12	3 45	3 23	3 6	2 52	2 41	2 24	2 11	2 2	1 56	1 50	1 47	1 44	1 42	1 40	34
35	4 57	4 18	3 50	3 28	3 10	2 56	2 44	2 27	2 14	2 4	1 57	1 51	1 47	1 44	1 42	1 40	35
36	5 4	4 24	3 55	3 32	3 14	3 0	2 47	2 29	2 16	2 6	1 58	1 52	1 48	1 45	1 43	1 41	36
37	5 11	4 29	4 0	3 37	3 19	3 3	2 50	2 32	2 18	2 8	2 0	1 53	1 49	1 46	1 44	1 42	37
38	5 18	4 35	4 5	3 42	3 23	3 7	2 54	2 34	2 20	2 9	2 1	1 54	1 49	1 46	1 44	1 42	38
39	5 25	4 41	4 10	3 46	3 27	3 11	2 58	2 36	2 22	2 10	2 2	1 55	1 50	1 47	1 45	1 43	39
40	5 31	4 47	4 15	3 50	3 31	3 14	3 1	2 38	2 24	2 12	2 4	1 57	1 51	1 47	1 45	1 43	40
41	5 38	4 52	4 20	3 54	3 35	3 18	3 4	2 41	2 26	2 14	2 5	1 58	1 52	1 48	1 46	1 44	41
42	5 44	4 57	4 25	3 58	3 38	3 21	3 7	2 44	2 28	2 16	2 7	1 59	1 53	1 49	1 46	1 44	42
43	5 51	5 3	4 30	4 2	3 42	3 25	3 10	2 46	2 30	2 17	2 8	2 1	1 55	1 50	1 47	1 45	43
44	5 57	5 8	4 35	4 6	3 46	3 28	3 13	2 48	2 32	2 19	2 10	2 2	1 56	1 51	1 48	1 45	44
46	6 9	5 18	4 44	4 14	3 53	3 35	3 19	2 53	2 36	2 23	2 13	2 4	1 58	1 53	1 49	1 46	46
48	6 20	5 28	4 53	4 22	4 0	3 41	3 25	2 58	2 39	2 26	2 15	2 7	2 0	1 55	1 51	1 48	48
50	6 31	5 38	5 1	4 30	4 6	3 47	3 30	3 3	2 43	2 29	2 18	2 9	2 2	1 56	1 52	1 49	50
52	6 41	5 47	5 9	4 37	4 12	3 53	3 35	3 7	2 47	2 32	2 21	2 12	2 4	1 58	1 54	1 50	52
54	6 51	5 56	5 17	4 44	4 18	3 58	3 39	3 11	2 51	2 35	2 24	2 14	2 6	1 59	1 55	1 52	54
56	7 1	6 5	5 24	4 50	4 24	4 3	3 44	3 15	2 54	2 38	2 26	2 17	2 8	2 1	1 57	1 53	56
58	7 11	6 14	5 31	4 56	4 30	4 8	3 49	3 19	2 57	2 41	2 29	2 19	2 10	2 3	1 58	1 54	58
60	7 20	6 22	5 38	5 2	4 35	4 13	3 54	3 23	3 0	2 44	2 31	2 21	2 12	2 5	1 59	1 55	60
62	7 28	6 29	5 44	5 7	4 40	4 18	3 58	3 27	3 3	2 47	2 33	2 22	2 13	2 6	2 0	1 56	62
64	7 36	6 35	5 50	5 12	4 44	4 22	4 2	3 31	3 6	2 49	2 35	2 24	2 15	2 7	2 1	1 56	64
66	7 43	6 41	5 55	5 17	4 49	4 26	4 6	3 34	3 9	2 51	2 37	2 26	2 16	2 8	2 2	1 57	66
68	7 49	6 46	6 0	5 21	4 53	4 30	4 9	3 37	3 12	2 53	2 39	2 27	2 17	2 9	2 3	1 58	68
70	7 55	6 51	6 5	5 25	4 57	4 33	4 12	3 39	3 14	2 55	2 41	2 29	2 19	2 10	2 4	1 59	70
72	8 0	6 55	6 9	5 29	5 0	4 36	4 14	3 41	3 16	2 57	2 42	2 30	2 20	2 11	2 5	2 0	72
74	8 5	6 59	6 13	5 32	5 3	4 38	4 16	3 43	3 18	2 58	2 43	2 31	2 21	2 12	2 5		74
76	8 9	7 3	6 16	5 35	5 6	4 40	4 18	3 44	3 19	2 59	2 44	2 32	2 22	2 13			76
78	8 13	7 6	6 19	5 37	5 8	4 42	4 19	3 45	3 20	3 0	2 45	2 32	2 22				78
80	8 16	7 9	6 21	5 40	5 10	4 44	4 21	3 46	3 21	3 1	2 45	2 33					80
82	8 19	7 12	6 23	5 42	5 12	4 45	4 22	3 47	3 22	3 2	2 46						82
84	8 22	7 14	6 25	5 44	5 13	4 46	4 23	3 48	3 23	3 3							84
86	8 24	7 15	6 27	5 46	5 14	4 47	4 24	3 49	3 24								86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 80°.

D's App. Alt.	Apparent Altitude of the Sun, Star or Planet.																D's App. Alt.
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	4 30	4 44	4 58	5 12	5 39	6 4	6 28	6 49	– 8	7 26	7 41	7 54	8 5	8 13	8 19	8 24	6
7	3 56	4 8	4 19	4 30	4 52	5 14	5 35	5 54	6 11	6 26	6 39	6 50	6 59	7 6	7 12	7 16	7
8	3 31	3 41	3 52	4 2	4 23	4 42	4 59	5 15	5 29	5 42	5 54	6 · 4	6 12	6 18	6 23	6 27	8
9	3 11	3 21	3 30	3 39	3 56	4 12	4 28	4 42	4 54	5 5	5 15	5 24	5 32	5 38	5 43	5 46	9
10	2 54	3 3	3 12	3 20	3 35	3 50	4 4	4 16	4 28	4 39	4 48	4 56	5 2	5 7	5 11	5 14	10
11	2 42	2 49	2 57	3 5	3 19	3 32	3 44	3 56	4 7	4 16	4 24	4 31	4 36	4 41	4 45	4 47	11
12	2 32	2 38	2 45	2 52	3 5	3 17	3 28	3 38	3 48	3 57	4 5	4 11	4 15	4 19	4 22	4 25	12
13	2 24	2 30	2 36	2 42	2 53	3 4	3 14	3 23	3 32	3 40	3 47	3 53	3 57	4 1	4 4	4 6	13
14	2 18	2 23	2 28	2 33	2 43	2 53	3 2	3 11	3 19	3 26	3 32	3 38	3 42	3 46	3 48	3 49	14
15	2 12	2 16	2 21	2 25	2 34	2 43	2 52	3 0	3 7	3 13	3 19	3 25	3 29	3 32	3 34	3 36	15
16	2 6	2 10	2 14	2 18	2 26	2 34	2 42	2 50	2 56	3 2	3 8	3 13	3 17	3 20	3 22	3 24	16
17	2 1	2 4	2 8	2 12	2 20	2 27	2 34	2 41	2 47	2 53	2 58	3 3	3 6	3 9	3 11		17
18	1 57	2 0	2 3	2 7	2 14	2 21	2 28	2 34	2 40	2 46	2 50	2 54	2 57	3 0	3 2		18
19	1 54	1 56	1 59	2 2	2 9	2 16	2 22	2 28	2 34	2 39	2 43	2 47	2 50	2 52	2 53		19
20	1 51	1 53	1 56	1 58	2 5	2 11	2 17	2 22	2 28	2 33	2 37	2 40	2 43	2 45	2 46		20
21	1 49	1 51	1 53	1 55	2 1	2 7	2 12	2 17	2 22	2 27	2 31	2 34	2 37	2 38			21
22	1 47	1 49	1 51	1 53	1 58	2 3	2 8	2 13	2 17	2 21	2 25	2 28	2 31	2 32			22
23	1 46	1 47	1 49	1 51	1 55	2 0	2 4	2 9	2 13	2 17	2 20	2 23	2 26	2 27			23
24	1 45	1 46	1 47	1 49	1 53	1 57	2 1	2 5	2 9	2 13	2 16	2 19	2 21	2 22			24
25	1 44	1 45	1 46	1 48	1 51	1 54	1 58	2 1	2 5	2 9	2 12	2 14	2 16				25
26	1 43	1 44	1 45	1 46	1 49	1 52	1 55	1 58	2 2	2 5	2 8	2 10	2 12				26
27	1 42	1 43	1 44	1 45	1 47	1 50	1 53	1 56	1 59	2 2	2 5	2 7	2 8				27
28	1 41	1 42	1 43	1 44	1 46	1 48	1 51	1 54	1 57	1 59	2 2	2 4	2 5				28
29	1 40	1 41	1 41	1 42	1 44	1 46	1 49	1 52	1 55	1 57	1 59	2 1					29
30	1 39	1 40	1 40	1 41	1 43	1 45	1 48	1 51	1 53	1 55	1 57	1 59					30
31	1 39	1 40	1 40	1 41	1 42	1 44	1 46	1 49	1 51	1 53	1 55	1 57					31
32	1 39	1 39	1 39	1 40	1 41	1 43	1 45	1 47	1 49	1 51	1 53	1 55					32
33	1 39	1 39	1 39	1 40	1 41	1 42	1 44	1 46	1 48	1 49	1 51						33
34	1 39	1 39	1 39	1 40	1 41	1 42	1 43	1 45	1 47	1 48	1 49						34
35	1 39	1 39	1 39	1 39	1 40	1 41	1 42	1 44	1 45	1 46	1 47						35
36	1 40	1 39	1 39	1 39	1 40	1 41	1 42	1 43	1 44	1 45	1 46						36
37	1 41	1 40	1 39	1 38	1 39	1 40	1 41	1 42	1 43	1 44							37
38	1 41	1 40	1 39	1 38	1 39	1 40	1 41	1 42	1 42	1 43							38
39	1 41	1 40	1 39	1 38	1 39	1 39	1 40	1 41	1 41	1 42							39
40	1 41	1 40	1 39	1 38	1 38	1 38	1 39	1 40	1 40	1 41							40
41	1 42	1 41	1 40	1 39	1 38	1 38	1 38	1 39	1 39								41
42	1 42	1 41	1 40	1 39	1 37	1 37	1 37	1 38	1 38								42
43	1 43	1 41	1 40	1 39	1 37	1 37	1 37	1 37	1 38								43
44	1 43	1 42	1 40	1 39	1 37	1 37	1 36	1 37	1 37								44
46	1 44	1 42	1 41	1 40	1 38	1 37	1 36	1 36									46
48	1 45	1 43	1 41	1 40	1 38	1 37	1 36	1 36									48
50	1 46	1 44	1 42	1 41	1 38	1 36	1 36										50
52	1 47	1 45	1 43	1 41	1 38	1 36	1 35										
54	1 48	1 46	1 44	1 42	1 38	1 36											
56	1 49	1 47	1 44	1 42	1 38	1 36											
58	1 50	1 47	1 45	1 42	1 38												
60	1 51	1 48	1 45	1 43	1 38												
62	1 52	1 49	1 46	1 43													
64	1 52	1 49	1 46	1 43													
66	1 53	1 49	1 46														
68	1 54	1 50															
70	1 55																
72																	
74																	
76																	
78																	
80																	
82																	
84																	
86																	
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°						

Table P. Effect of Sun's Par.

Add the Numbers above the lines to Third Correction; subtract the others.

D's App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	1	1	1	0	0	1	1	1	1	
10	1	1	1	1	1	0	0	0	0	
15	2	2	2	2	1	1	1	1	1	0
20	3	3	3	2	2	2	2	2	2	
25	4	4	3	3	3	3	3	2		
30	1	4	4	4	4	3	3	3		
35	5	5	5	4	4	4	4			
40	6	6	5	5	5	5	4			
45	6	6	6	6	5	5				
50	7	7	6	6	6	6				
55	7	7	7	7	6					
60	8	8	7	7	7					
65	8	8	8	8						
70	8	8	8	8						
75	9	9	9							
80	9	9	8							
90		9								

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 84°.

☽'s App. Alt.	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	☽'s App Alt.
	Apparent Altitude of the Sun, Star or Planet.																
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	′	′ ″	′ ″	′ ″	′ ″	°
6	1 47	1 49	1 51	1 54	1 59	2 4	2 10	2 22	2 36	2 50	3 5	3 20	3 35	3 50	4 5	4 20	6
7	1 50	1 47	1 48	1 50	1 53	1 56	2 0	2 10	2 21	2 33	2 45	2 57	3 10	3 23	3 35	3 48	7
8	1 53	1 49	1 47	1 48	1 50	1 52	1 55	2 2	2 11	2 21	2 31	2 42	2 53	3 3	3 14	3 25	8
9	1 57	1 52	1 49	1 47	1 48	1 50	1 52	1 57	2 4	2 12	2 2[illegible]	2 30	2 39	2 48	2 58	3 7	9
10	2 2	1 55	1 51	1 49	1 47	1 48	1 50	1 53	1 59	2 5	2 12	2 20	2 27	2 35	2 44	2 52	10
11	2 8	1 59	1 54	1 51	1 49	1 47	1 48	1 51	1 55	1 59	2 5	2 12	2 18	2 26	2 33	2 41	11
12	2 14	2 4	1 57	1 53	1 51	1 48	1 47	1 49	1 52	1 55	1 59	2 5	2 11	2 18	2 25	2 31	12
13	2 20	2 9	2 1	1 56	1 53	1 50	1 48	1 48	1 50	1 52	1 55	2 0	2 6	2 11	2 17	2 23	13
14	2 27	2 14	2 5	1 59	1 55	1 52	1 50	1 47	1 48	1 50	1 53	1 57	2 2	2 6	2 11	2 16	14
15	2 34	2 20	2 10	2 3	1 58	1 54	1 51	1 48	1 47	1 49	1 51	1 54	1 58	2 2	2 7	2 11	15
16	2 42	2 26	2 15	2 7	2 1	1 56	1 53	1 49	1 47	1 48	1 50	1 52	1 55	1 59	2 3	2 7	16
17	2 49	2 32	2 20	2 11	2 4	1 59	1 55	1 50	1 48	1 47	1 48	1 50	1 53	1 56	2 0	2 3	17
18	2 57	2 38	2 25	2 16	2 8	2 2	1 57	1 52	1 49	1 46	1 47	1 49	1 51	1 54	1 57	2 0	18
19	3 4	2 44	2 31	2 20	2 12	2 5	1 59	1 53	1 50	1 47	1 46	1 48	1 49	1 52	1 54	1 57	19
20	3 12	2 50	2 36	2 25	2 15	2 8	2 2	1 55	1 51	1 48	1 46	1 47	1 48	1 50	1 52	1 55	20
21	3 20	2 57	2 42	2 29	2 19	2 11	2 5	1 57	1 52	1 49	1 47	1 46	1 47	1 48	1 50	1 52	21
22	3 27	3 3	2 47	2 34	2 23	2 14	2 8	1 59	1 54	1 50	1 47	1 46	1 46	1 47	1 49	1 50	22
23	3 35	3 9	2 52	2 38	2 27	2 18	2 11	2 1	1 56	1 52	1 48	1 46	1 46	1 47	1 48	1 49	23
24	3 42	3 15	2 57	2 42	2 30	2 21	2 14	2 3	1 57	1 53	1 49	1 46	1 46	1 46	1 47	1 48	24
25	3 49	3 21	3 3	2 47	2 34	2 25	2 17	2 6	1 59	1 54	1 50	1 47	1 46	1 46	1 46	1 47	25
26	3 56	3 27	3 8	2 52	2 38	2 28	2 20	2 8	2 0	1 55	1 51	1 48	1 47	1 46	1 46	1 46	26
27	4 4	3 34	3 13	2 56	2 42	2 32	2 24	2 11	2 2	1 56	1 52	1 49	1 47	1 46	1 45	1 46	27
28	4 11	3 40	3 18	3 1	2 46	2 35	2 27	2 13	2 4	1 58	1 53	1 49	1 47	1 46	1 45	1 45	28
29	4 19	3 47	3 24	3 5	2 51	2 39	2 30	2 16	2 6	1 59	1 54	1 50	1 48	1 46	1 45	1 45	29
30	4 26	3 53	3 29	3 10	2 55	2 43	2 33	2 18	2 8	2 1	1 55	1 51	1 49	1 47	1 46	1 45	30
31	4 33	3 59	3 35	3 14	2 59	2 46	2 36	2 21	2 10	2 3	1 57	1 52	1 49	1 47	1 46	1 45	31
32	4 40	4 5	3 40	3 19	3 3	2 50	2 39	2 24	2 12	2 4	1 58	1 53	1 50	1 48	1 46	1 45	32
33	4 47	4 11	3 45	3 24	3 7	2 54	2 42	2 27	2 14	2 5	1 59	1 54	1 50	1 48	1 46	1 45	33
34	4 54	4 16	3 50	3 28	3 11	2 57	2 45	2 29	2 16	2 7	2 0	1 55	1 51	1 48	1 47	1 46	34
35	5 1	4 22	3 55	3 33	3 15	3 1	2 49	2 32	2 19	2 9	2 2	1 56	1 52	1 49	1 47	1 46	35
36	5 8	4 28	4 0	3 37	3 19	3 5	2 52	2 34	2 21	2 10	2 3	1 58	1 53	1 49	1 47	1 46	36
37	5 15	4 34	4 5	3 42	3 23	3 8	2 56	2 37	2 23	2 12	2 4	1 59	1 54	1 50	1 48	1 47	37
38	5 21	4 40	4 10	3 46	3 27	3 12	2 59	2 39	2 25	2 14	2 6	2 0	1 55	1 51	1 49	1 47	38
39	5 28	4 45	4 15	3 51	3 31	3 15	3 2	2 42	2 27	2 16	2 7	2 1	1 56	1 52	1 49	1 47	39
40	5 34	4 51	4 20	3 55	3 35	3 19	3 5	2 44	2 29	2 18	2 9	2 3	1 57	1 52	1 49	1 47	40
41	5 41	4 56	4 25	3 59	3 39	3 23	3 8	2 47	2 31	2 20	2 11	2 4	1 58	1 53	1 50	1 48	41
42	5 47	5 1	4 30	4 3	3 43	3 26	3 11	2 49	2 33	2 21	2 12	2 5	1 59	1 54	1 51	1 49	42
43	5 53	5 7	4 35	4 7	3 47	3 30	3 14	2 52	2 35	2 23	2 13	2 7	2 0	1 55	1 52	1 50	43
44	6 0	5 12	4 40	4 11	3 50	3 34	3 17	2 54	2 37	2 25	2 15	2 8	2 1	1 56	1 53	1 51	44
46	6 12	5 22	4 49	4 19	3 57	3 40	3 23	2 59	2 41	2 29	2 18	2 10	2 3	1 58	1 55	1 52	46
48	6 24	5 32	4 58	4 27	4 4	3 46	3 29	3 4	2 45	2 32	2 21	2 12	2 5	2 0	1 56	1 53	48
50	6 35	5 42	5 6	4 35	4 11	3 52	3 35	3 9	2 49	2 35	2 24	2 15	2 8	2 2	1 58	1 55	50
52	6 45	5 51	5 14	4 42	4 17	3 58	3 40	3 13	2 53	2 38	2 27	2 18	2 10	2 4	2 0	1 57	52
54	6 55	6 0	5 22	4 49	4 23	4 4	3 45	3 17	2 57	2 41	2 30	2 20	2 12	2 6	2 2	1 58	54
56	7 5	6 9	5 29	4 55	4 29	4 9	3 50	3 21	3 1	2 44	2 32	2 22	2 14	2 8	2 3	1 59	56
58	7 14	6 17	5 36	5 1	4 34	4 14	3 55	3 25	3 4	2 47	2 35	2 24	2 16	2 9	2 4	2 0	58
60	7 22	6 25	5 42	5 6	4 39	4 19	3 59	3 29	3 7	2 50	2 37	2 26	2 17	2 10	2 5	2 1	60
62	7 30	6 32	5 48	5 11	4 44	4 23	4 3	3 33	3 10	2 53	2 39	2 28	2 19	2 12	2 7	2 2	62
64	7 38	6 39	5 54	5 16	4 49	4 27	4 7	3 36	3 13	2 56	2 41	2 29	2 20	2 13	2 8	2 3	64
66	7 45	6 45	6 0	5 21	4 54	4 31	4 11	3 39	3 16	2 58	2 43	2 31	2 22	2 15	2 9	2 3	66
68	7 51	6 50	6 5	5 25	4 58	4 35	4 15	3 41	3 19	3 0	2 45	2 33	2 24	2 16	2 10	2 4	68
70	7 57	6 54	6 9	5 29	5 2	4 39	4 18	3 44	3 21	3 2	2 46	2 34	2 25	2 17	2 10		70
72	8 2	6 58	6 13	5 33	5 6	4 42	4 21	3 46	3 23	3 3	2 47	2 35	2 26	2 18			72
74	8 6	7 2	6 17	5 36	5 9	4 44	4 23	3 48	3 24	3 4	2 48	2 36	2 27				74
76	8 10	7 5	6 20	5 39	5 11	4 46	4 25	3 50	3 25	3 5	2 49	2 37					76
78	8 14	7 8	6 23	5 42	5 13	4 48	4 26	3 51	3 26	3 6	2 50						78
80	8 18	7 11	6 26	5 45	5 15	4 50	4 27	3 52	3 27	3 7							80
82	8 21	7 14	6 28	5 47	5 17	4 51	4 28	3 53	3 28								82
84	8 24	7 17	6 30	5 49	5 18	4 52	4 29	3 54									84
86	8 26	7 19	6 31	5 50	5 19	4 53	4 30										86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 84°.

☽'s App. Alt.	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	☽'s App. Alt.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	4 34	4 48	5 2	5 15	5 41	6 6	6 29	6 51	7 10	7 27	7 42	7 55	8 6	8 14	8 21	8 27	6
7	4 0	4 12	4 24	4 36	4 58	5 19	5 39	5 58	6 15	6 30	6 42	6 53	7 2	7 9	7 15	7 19	7
8	3 36	3 47	3 57	4 7	4 27	4 46	5 4	5 20	5 34	5 46	5 58	6 9	6 17	6 23	6 28	6 31	8
9	3 16	3 25	3 34	3 43	4 0	4 17	4 33	4 47	4 59	5 10	5 20	5 29	5 36	5 42	5 47	5 50	9
10	3 1	3 9	3 17	3 25	3 41	3 55	4 9	4 21	4 33	4 43	4 53	5 1	5 7	5 13	5 17	5 19	10
11	2 48	2 55	3 3	3 10	3 24	3 37	3 50	4 2	4 12	4 21	4 30	4 37	4 43	4 48	4 51	4 54	11
12	2 38	2 44	2 51	2 58	3 10	3 22	3 34	3 45	3 54	4 2	4 10	4 16	4 22	4 26	4 28	4 30	12
13	2 29	2 35	2 41	2 47	2 58	3 9	3 20	3 29	3 38	3 45	3 52	3 58	4 3	4 7	4 9		13
14	2 22	2 27	2 33	2 38	2 48	2 58	3 8	3 16	3 24	3 31	3 37	3 43	3 47	3 51	3 53		14
15	2 16	2 21	2 26	2 30	2 39	2 48	2 57	3 5	3 12	3 19	3 25	3 30	3 34	3 37	3 40		15
16	2 11	2 15	2 20	2 24	2 32	2 40	2 48	2 56	3 2	3 9	3 15	3 19	3 23	3 26	3 29		16
17	2 7	2 10	2 14	2 18	2 26	2 34	2 41	2 48	2 54	3 0	3 5	3 9	3 13	3 15			17
18	2 3	2 6	2 10	2 13	2 21	2 28	2 34	2 40	2 46	2 52	2 57	3 1	3 4	3 6			18
19	2 0	2 3	2 6	2 9	2 16	2 23	2 29	2 34	2 40	2 45	2 49	2 53	2 56	2 58			19
20	1 57	2 0	2 2	2 5	2 12	2 18	2 24	2 29	2 34	2 38	2 42	2 45	2 48	2 50			20
21	1 54	1 57	1 59	2 2	2 8	2 13	2 19	2 24	2 29	2 33	2 36	2 39	2 41				21
22	1 52	1 54	1 56	1 59	2 4	2 9	2 14	2 19	2 24	2 28	2 31	2 34	2 36				22
23	1 50	1 52	1 54	1 56	2 1	2 5	2 10	2 15	2 19	2 23	2 26	2 29	2 32				23
24	1 49	1 50	1 52	1 54	1 58	2 2	2 7	2 11	2 15	2 19	2 22	2 25	2 28				24
25	1 48	1 49	1 50	1 52	1 56	2 0	2 4	2 8	2 12	2 15	2 18	2 21					25
26	1 47	1 48	1 49	1 51	1 54	1 58	2 2	2 5	2 9	2 12	2 15	2 17					26
27	1 47	1 48	1 49	1 50	1 53	1 56	2 0	2 3	2 6	2 9	2 12	2 14					27
28	1 46	1 47	1 48	1 49	1 51	1 54	1 58	2 1	2 3	2 6	2 9	2 11					28
29	1 46	1 47	1 47	1 48	1 50	1 53	1 56	1 59	2 1	2 4	2 6						29
30	1 45	1 46	1 46	1 47	1 49	1 52	1 55	1 57	2 0	2 2	2 3						30
31	1 45	1 45	1 46	1 47	1 49	1 51	1 54	1 56	1 58	2 0	2 1						31
32	1 45	1 45	1 45	1 46	1 48	1 50	1 52	1 54	1 56	1 58	1 59						32
33	1 45	1 45	1 45	1 46	1 47	1 49	1 51	1 53	1 54	1 56							33
34	1 45	1 44	1 44	1 45	1 46	1 48	1 50	1 52	1 53	1 54							34
35	1 45	1 44	1 44	1 45	1 46	1 47	1 49	1 50	1 51	1 52							35
36	1 46	1 45	1 44	1 44	1 45	1 46	1 48	1 49	1 50	1 50							36
37	1 46	1 45	1 44	1 44	1 45	1 45	1 47	1 48	1 49								37
38	1 46	1 45	1 44	1 44	1 44	1 45	1 46	1 47	1 48								38
39	1 46	1 45	1 44	1 44	1 44	1 44	1 45	1 46	1 47								39
40	1 46	1 45	1 45	1 45	1 44	1 44	1 45	1 45	1 46								40
41	1 47	1 46	1 45	1 45	1 44	1 44	1 44	1 44									41
42	1 48	1 47	1 46	1 45	1 43	1 43	1 44	1 44									42
43	1 49	1 48	1 46	1 45	1 43	1 43	1 44	1 44									43
44	1 49	1 48	1 47	1 45	1 43	1 43	1 43										44
46	1 50	1 49	1 47	1 45	1 43	1 43	1 43										46
48	1 51	1 50	1 48	1 46	1 44	1 43	1 42										48
50	1 53	1 51	1 49	1 47	1 44	1 43											50
52	1 54	1 51	1 49	1 47	1 44	1 42											
54	1 55	1 52	1 49	1 47	1 44												
56	1 56	1 53	1 50	1 48	1 44												
58	1 56	1 53	1 50	1 48													
60	1 57	1 54	1 51	1 48													
62	1 58	1 54	1 51														
64	1 59	1 55															
66	1 59																
68																	
70																	
72																	
74																	
76																	
78																	
80																	
82																	
84																	
86																	
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°						

Table P. Effect of Sun's Par.

To be subtracted from the third Correction.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	1	1	1	0	0	0	0	0	0	
10	1	1	1	1	1	1	1	1	1	0
15	2	2	2	2	2	2	2	2	1	
20	3	3	3	3	2	2	2	2		
25	4	4	3	3	3	3	3	3		
30	4	4	4	4	4	4	4	4		
35	5	5	5	5	5	4	4			
40	6	6	5	5	5	5	5			
45	6	6	6	6	6	6				
50	7	7	7	6	6					
55	7	7	7	7	7					
60	8	8	7	7						
65	8	8	8	8						
70	8	8	8							
75	9	9	8							
80	9	9								
90	9									

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 88°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App Alt
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	′ ″	′ ″	′ ″	′ ″	′ ′	′ ″	′ ′	″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 53	1 54	1 56	1 59	2 4	2 10	2 16	2 28	2 42	2 56	3 11	3 26	3 41	3 56	4 11	4 25	6
7	1 55	1 53	1 54	1 56	1 59	2 3	2 -	2 16	2 27	2 39	2 51	3 4	3 16	3 28	3 40	3 52	7
8	1 58	1 55	1 53	1 54	1 56	1 59	2 2	2 8	2 17	2 27	2 37	2 48	2 59	3 9	3 19	3 30	8
9	2 2	1 58	1 55	1 53	1 54	1 56	1 58	2 3	2 10	2 18	2 26	2 35	2 45	2 54	3 3	3 12	9
10	2 7	2 1	1 57	1 55	1 53	1 54	1 56	2 0	2 5	2 11	2 18	2 25	2 34	2 43	2 50	2 58	10
11	2 13	2 5	2 0	1 57	1 55	1 53	1 54	1 57	2 1	2 6	2 12	2 18	2 25	2 32	2 39	2 47	11
12	2 19	2 10	2 4	2 0	1 57	1 54	1 53	1 55	1 58	2 2	2 7	2 12	2 18	2 24	2 30	2 37	12
13	2 26	2 15	2 8	2 3	1 59	1 56	1 54	1 54	1 56	1 59	2 3	2 7	2 12	2 18	2 23	2 29	13
14	2 33	2 21	2 12	2 6	2 1	1 58	1 56	1 53	1 55	1 57	2 0	2 3	2 7	2 12	2 17	2 22	14
15	2 40	2 26	2 16	2 9	2 4	2 0	1 57	1 54	1 54	1 55	1 58	2 0	2 4	2 8	2 13	2 17	15
16	2 47	2 32	2 20	2 13	2 7	2 2	1 59	1 55	1 53	1 54	1 56	1 58	2 1	2 5	2 9	2 13	16
17	2 54	2 37	2 25	2 17	2 10	2 5	2 1	1 56	1 53	1 53	1 55	1 57	1 59	2 2	2 5	2 9	17
18	3 2	2 43	2 30	2 21	2 13	2 7	2 3	1 58	1 54	1 52	1 54	1 56	1 58	2 0	2 2	2 5	18
19	3 10	2 49	2 35	2 25	2 16	2 10	2 5	1 59	1 55	1 53	1 53	1 54	1 56	1 58	2 0	2 3	19
20	3 17	2 55	2 41	2 29	2 20	2 13	2 8	2 1	1 56	1 54	1 52	1 53	1 54	1 56	1 58	2 1	20
21	3 25	3 2	2 46	2 34	2 24	2 17	2 11	2 3	1 58	1 55	1 53	1 52	1 53	1 55	1 57	1 59	21
22	3 32	3 8	2 52	2 39	2 28	2 20	2 14	2 5	1 59	1 56	1 53	1 52	1 53	1 54	1 55	1 57	22
23	3 40	3 15	2 57	2 43	2 32	2 24	2 17	2 7	2 1	1 57	1 54	1 52	1 52	1 53	1 54	1 55	23
24	3 47	3 21	3 2	2 48	2 36	2 27	2 20	2 9	2 2	1 58	1 55	1 53	1 52	1 52	1 53	1 54	24
25	3 55	3 27	3 8	2 52	2 40	2 31	2 23	2 11	2 4	2 0	1 56	1 53	1 52	1 52	1 53	1 54	25
26	4 2	3 33	3 13	2 57	2 44	2 35	2 27	2 14	2 6	2 1	1 57	1 54	1 53	1 52	1 52	1 53	26
27	4 10	3 39	3 18	3 2	2 48	2 38	2 30	2 17	2 8	2 2	1 58	1 55	1 53	1 52	1 52	1 52	27
28	4 17	3 45	3 23	3 6	2 52	2 42	2 33	2 19	2 10	2 4	1 59	1 55	1 53	1 52	1 52	1 52	28
29	4 24	3 51	3 28	3 11	2 56	2 46	2 37	2 22	2 12	2 5	2 0	1 56	1 53	1 52	1 52	1 52	29
30	4 31	3 57	3 34	3 15	3 0	2 49	2 40	2 24	2 14	2 6	2 1	1 57	1 54	1 53	1 52	1 52	30
31	4 39	4 3	3 40	3 20	3 4	2 53	2 43	2 27	2 16	2 8	2 2	1 58	1 55	1 53	1 52	1 52	31
32	4 40	4 9	3 45	3 25	3 8	2 56	2 46	2 29	2 18	2 9	2 3	1 59	1 56	1 54	1 53	1 52	32
33	4 53	4 15	3 51	3 29	3 12	3 0	2 50	2 31	2 20	2 11	2 5	2 0	1 56	1 54	1 53	1 53	33
34	5 0	4 21	3 56	3 34	3 17	3 4	2 53	2 34	2 22	2 13	2 7	2 1	1 57	1 55	1 54	1 53	34
35	5 7	4 27	4 1	3 38	3 21	3 7	2 56	2 37	2 24	2 15	2 8	2 2	1 58	1 56	1 54	1 53	35
36	5 13	4 33	4 6	3 43	3 25	3 11	2 59	2 40	2 26	2 17	2 10	2 4	1 59	1 56	1 54	1 53	36
37	5 20	4 39	4 11	3 48	3 29	3 15	3 2	2 43	2 28	2 19	2 11	2 5	2 0	1 57	1 55	1 54	37
38	5 27	4 45	4 16	3 52	3 33	3 18	3 5	2 46	2 31	2 21	2 13	2 6	2 1	1 58	1 56	1 54	38
39	5 34	4 51	4 21	3 57	3 37	3 22	3 8	2 49	2 33	2 22	2 14	2 7	2 2	1 58	1 56	1 55	39
40	5 40	4 56	4 26	4 1	3 41	3 25	3 11	2 51	2 35	2 24	2 16	2 9	2 3	1 59	1 57	1 55	40
41	5 47	5 2	4 31	4 5	3 45	3 29	3 14	2 54	2 38	2 26	2 17	2 10	2 4	2 0	1 57	1 55	41
42	5 53	5 7	4 36	4 9	3 49	3 32	3 17	2 56	2 40	2 28	2 19	2 11	2 5	2 1	1 58	1 56	42
43	6 0	5 13	4 41	4 14	3 53	3 36	3 20	2 59	2 42	2 30	2 20	2 12	2 6	2 2	1 59	1 57	43
44	6 6	5 19	4 46	4 18	3 57	3 39	3 23	3 1	2 44	2 32	2 22	2 13	2 7	2 3	2 0	1 58	44
46	6 18	5 29	4 55	4 26	4 4	3 46	3 29	3 6	2 48	2 35	2 25	2 16	2 9	2 5	2 2	1 59	46
48	6 29	5 39	5 4	4 34	4 11	3 52	3 35	3 11	2 52	2 39	2 28	2 18	2 11	2 7	2 3	2 0	48
50	6 40	5 48	5 12	4 41	4 17	3 58	3 41	3 15	2 56	2 42	2 31	2 21	2 13	2 9	2 5	2 2	50
52	6 51	5 57	5 20	4 48	4 23	4 2	3 47	3 19	2 59	2 45	2 34	2 24	2 16	2 10	2 6	2 3	52
54	7 1	6 6	5 28	4 55	4 29	4 8	3 52	3 23	3 3	2 48	2 36	2 27	2 18	2 12	2 8	2 4	54
56	7 10	6 15	5 35	5 1	4 35	4 14	3 57	3 27	3 7	2 51	2 39	2 29	2 20	2 14	2 9	2 5	56
58	7 19	6 23	5 42	5 7	4 40	4 19	4 2	3 31	3 10	2 54	2 42	2 31	2 22	2 16	2 11	2 6	58
60	7 28	6 31	5 48	5 12	4 45	4 24	4 6	3 35	3 13	2 57	2 44	2 33	2 24	2 17	2 12	2 7	60
62	7 36	6 38	5 54	5 17	4 50	4 29	4 10	3 38	3 16	2 59	2 46	2 35	2 26	2 19	2 13	2 8	62
64	7 44	6 45	6 0	5 22	4 55	4 33	4 14	3 42	3 19	3 2	2 48	2 37	2 28	2 20	2 14	2 9	64
66	7 51	6 51	6 5	5 27	5 0	4 37	4 18	3 45	3 22	3 4	2 50	2 39	2 30	2 22	2 15		66
68	7 58	6 56	6 10	5 32	5 4	4 41	4 21	3 48	3 25	3 6	2 51	2 40	2 31	2 23			68
70	8 4	7 1	6 15	5 36	5 8	4 44	4 23	3 50	3 27	3 8	2 53	2 41	2 32				70
72	8 10	7 5	6 19	5 40	5 11	4 47	4 25	3 52	3 29	3 9	2 53	2 42					72
74	8 15	7 9	6 23	5 43	5 14	4 49	4 27	3 54	3 30	3 10	2 54						74
76	8 19	7 13	6 26	5 46	5 17	4 51	4 29	3 56	3 31	3 11							76
78	8 22	7 16	6 29	5 49	5 19	4 53	4 31	3 57	3 32								78
80	8 25	7 19	6 31	5 52	5 21	4 55	4 33	3 58									80
82	8 28	7 22	6 33	5 54	5 23	4 57	4 35										82
84	8 30	7 24	6 35	5 56	5 25												84
86	8 32	7 26	6 37														86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 88°.

☽ App. Alt.	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	☽'s App. Alt.
	Apparent Altitude of the Sun, Star or Planet.																
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′	′ ″	′ ″	°
6	4 40	4 54	5 8	5 22	5 48	6 13	6 36	6 57	7 16	7 34	7 49	8 2	8 13	8 21	8 27	8 32	6
7	4 4	4 16	4 28	4 40	5 3	5 25	5 45	6 4	6 21	6 36	6 49	7 0	7 9	7 16	7 22	7 27	7
8	3 41	3 52	4 3	4 13	4 33	4 52	5 10	5 26	5 40	5 53	6 5	6 15	6 23	6 29	6 34	6 37	8
9	3 22	3 31	3 41	3 50	4 8	4 24	4 39	4 53	5 5	5 16	5 26	5 35	5 43	5 49	5 54		9
10	3 6	3 14	3 22	3 30	3 46	4 1	4 15	4 27	4 38	4 49	4 58	5 7	5 14	5 19	5 23		10
11	2 54	3 2	3 9	3 16	3 30	3 43	3 56	4 7	4 17	4 27	4 36	4 43	4 49	4 53	4 57		11
12	2 44	2 51	2 58	3 4	3 16	3 28	3 40	3 50	4 0	4 8	4 16	4 23	4 28	4 32	4 36		12
13	2 35	2 41	2 47	2 53	3 4	3 15	3 26	3 35	3 44	3 52	3 59	4 5	4 10	4 13			13
14	2 27	2 33	2 38	2 44	2 54	3 4	3 14	3 22	3 30	3 37	3 44	3 50	3 54	3 57			14
15	2 22	2 27	2 32	2 36	2 46	2 55	3 4	3 11	3 18	3 25	3 31	3 37	3 41	3 44			15
16	2 17	2 21	2 26	2 30	2 39	2 47	2 55	3 2	3 9	3 15	3 21	3 26	3 30	3 33			16
17	2 12	2 16	2 21	2 25	2 33	2 40	2 47	2 54	3 0	3 6	3 12	3 16	3 19				17
18	2 8	2 12	2 16	2 20	2 27	2 34	2 41	2 47	2 53	2 58	3 3	3 7	3 10				18
19	2 5	2 8	2 12	2 16	2 22	2 29	2 35	2 41	2 47	2 52	2 56	2 59	3 2				19
20	2 3	2 6	2 9	2 12	2 18	2 24	2 30	2 35	2 41	2 46	2 49	2 52	2 54				20
21	2 1	2 3	2 6	2 8	2 14	2 19	2 25	2 30	2 35	2 40	2 43	2 46					21
22	1 59	2 1	2 3	2 5	2 10	2 15	2 20	2 25	2 30	2 35	2 38	2 41					22
23	1 57	1 59	2 1	2 3	2 7	2 12	2 16	2 21	2 26	2 30	2 33	2 36					23
24	1 56	1 57	1 59	2 1	2 5	2 9	2 13	2 17	2 22	2 26	2 29	2 31					24
25	1 55	1 56	1 57	1 59	2 3	2 6	2 10	2 14	2 18	2 22	2 25						25
26	1 54	1 55	1 56	1 58	2 1	2 4	2 8	2 12	2 15	2 18	2 21						26
27	1 53	1 54	1 55	1 57	2 0	2 3	2 6	2 10	2 13	2 15	2 17						27
28	1 53	1 54	1 55	1 56	1 58	2 1	2 4	2 8	2 11	2 13	2 14						28
29	1 52	1 53	1 54	1 55	1 57	2 0	2 3	2 6	2 8	2 10							29
30	1 52	1 53	1 53	1 54	1 56	1 59	2 2	2 4	2 6	2 8							30
31	1 52	1 52	1 52	1 53	1 55	1 58	2 0	2 2	2 4	2 5							31
32	1 51	1 52	1 52	1 53	1 55	1 57	1 59	2 1	2 2	2 3							32
33	1 52	1 51	1 51	1 52	1 54	1 56	1 58	1 59	2 0								33
34	1 52	1 51	1 51	1 52	1 53	1 55	1 57	1 58	1 59								34
35	1 52	1 51	1 51	1 51	1 52	1 54	1 56	1 57	1 57								35
36	1 53	1 52	1 51	1 51	1 52	1 53	1 55	1 56	1 56								36
37	1 53	1 52	1 51	1 51	1 51	1 52	1 54	1 55									37
38	1 53	1 52	1 51	1 50	1 51	1 52	1 53	1 54									38
39	1 54	1 52	1 51	1 50	1 51	1 52	1 52	1 53									39
40	1 54	1 53	1 52	1 51	1 50	1 51	1 52	1 52									40
41	1 54	1 53	1 52	1 51	1 50	1 51	1 51										41
42	1 54	1 53	1 52	1 51	1 50	1 51	1 51										42
43	1 55	1 54	1 53	1 52	1 51	1 51	1 51										43
44	1 56	1 54	1 53	1 52	1 51	1 50	1 50										44
46	1 57	1 55	1 53	1 52	1 51	1 50											46
48	1 58	1 56	1 54	1 53	1 51	1 50											48
50	1 59	1 57	1 55	1 53	1 51												50
52	2 0	1 58	1 55	1 53	1 52												
54	2 1	1 58	1 56	1 54													
56	2 2	1 59	1 56	1 54													
58	2 3	1 59	1 56														
60	2 3	1 59															
62	2 4																
64																	
66																	
68																	
70																	
72																	
74																	
76																	
78																	
80																	
82																	
84																	
86																	
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°						

Table P. *Effect of Sun's Par.*

To be subtracted from the third Correction.

☽'s App. Alt.	5	10	20	30	40	50	60	70	80	90
	Sun's Apparent Altitude.									
	″	″	″	″	″	″	″	″	″	″
5	1	1	1	1	1	1	1	0	0	
10	2	1	1	1	1	1	1	1	1	0
15	2	2	2	2	2	2	2	2	2	
20	3	3	3	3	3	3	3	3		
25	4	4	4	4	4	4	4	4		
30	4	4	4	4	4	4	4			
35	5	5	5	5	5	5	5			
40	6	6	6	6	6					
45	6	6	6	6	6					
50	7	7	7	7	7					
55	7	7	7	7	7					
60	8	8	8	8						
65	8	8	8							
70	8	8	8							
75	9	9								
80	9	9								
90	9									

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 88°.

☽'s App. Alt.	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	☽'s App. Alt.
	Apparent Altitude of the Sun, Star or Planet.																
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 53	1 54	1 56	1 59	2 4	2 10	2 16	2 28	2 42	2 56	3 11	3 26	3 41	3 56	4 11	4 25	6
7	1 55	1 53	1 54	1 56	1 59	2 3	2 [illegible]	2 16	2 27	2 39	2 51	3 4	3 16	3 28	3 40	3 52	7
8	1 58	1 55	1 53	1 54	1 56	1 59	2 2	2 8	2 17	2 27	2 37	2 46	2 59	3 9	3 19	3 30	8
9	2 2	1 58	1 55	1 53	1 54	1 56	1 58	2 3	2 10	2 18	2 26	2 35	2 45	2 54	3 3	3 12	9
10	2 7	2 1	1 57	1 55	1 53	1 54	1 56	2 0	2 5	2 11	2 18	2 25	2 34	2 43	2 50	2 58	10
11	2 13	2 5	2 0	1 57	1 55	1 53	1 54	1 57	2 1	2 6	2 12	2 18	2 25	2 32	2 39	2 47	11
12	2 19	2 10	2 4	2 0	1 57	1 54	1 53	1 55	1 58	2 2	2 7	2 12	2 18	2 24	2 30	2 37	12
13	2 26	2 15	2 8	2 3	1 59	1 56	1 54	1 54	1 56	1 59	2 3	2 7	2 12	2 18	2 23	2 29	13
14	2 33	2 21	2 12	2 6	2 1	1 58	1 56	1 53	1 55	1 57	2 0	2 3	2 7	2 12	2 17	2 22	14
15	2 40	2 26	2 16	2 9	2 4	2 0	1 57	1 54	1 54	1 55	1 58	2 0	2 4	2 8	2 13	2 17	15
16	2 47	2 32	2 20	2 13	2 7	2 2	1 59	1 55	1 53	1 54	1 56	1 58	2 1	2 5	2 9	2 13	16
17	2 54	2 37	2 25	2 17	2 10	2 5	2 1	1 56	1 53	1 53	1 55	1 57	1 59	2 2	2 5	2 9	17
18	3 2	2 43	2 30	2 21	2 13	2 7	2 3	1 58	1 54	1 52	1 54	1 56	1 58	2 0	2 2	2 5	18
19	3 10	2 49	2 35	2 25	2 16	2 10	2 5	1 59	1 55	1 53	1 53	1 54	1 56	1 58	2 0	2 3	19
20	3 17	2 55	2 41	2 29	2 20	2 13	2 8	2 1	1 56	1 54	1 52	1 53	1 54	1 56	1 58	2 1	20
21	3 25	3 2	2 46	2 34	2 24	2 17	2 11	2 3	1 58	1 55	1 53	1 52	1 53	1 55	1 57	1 59	21
22	3 32	3 8	2 52	2 39	2 28	2 20	2 14	2 5	1 59	1 56	1 53	1 52	1 53	1 54	1 55	1 57	22
23	3 40	3 15	2 57	2 43	2 32	2 24	2 17	2 7	2 1	1 57	1 54	1 52	1 52	1 53	1 54	1 55	23
24	3 47	3 21	3 2	2 48	2 36	2 27	2 20	2 9	2 2	1 58	1 55	1 53	1 52	1 52	1 53	1 54	24
25	3 55	3 27	3 8	2 52	2 40	2 31	2 23	2 11	2 4	2 0	1 56	1 53	1 52	1 52	1 53	1 54	25
26	4 2	3 33	3 13	2 57	2 44	2 35	2 27	2 14	2 6	2 1	1 57	1 54	1 53	1 52	1 52	1 53	26
27	4 10	3 39	3 18	3 2	2 48	2 38	2 30	2 17	2 8	2 2	1 58	1 55	1 53	1 52	1 52	1 52	27
28	4 17	3 45	3 23	3 6	2 52	2 42	2 33	2 19	2 10	2 4	1 59	1 55	1 53	1 52	1 52	1 52	28
29	4 24	3 51	3 28	3 11	2 56	2 46	2 37	2 22	2 12	2 5	2 0	1 56	1 53	1 52	1 52	1 52	29
30	4 31	3 57	3 34	3 15	3 0	2 49	2 40	2 24	2 14	2 6	2 1	1 57	1 54	1 53	1 52	1 52	30
31	4 39	4 3	3 40	3 20	3 4	2 53	2 43	2 27	2 16	2 8	2 2	1 58	1 55	1 53	1 52	1 52	31
32	4 46	4 9	3 45	3 25	3 8	2 56	2 46	2 29	2 18	2 9	2 3	1 59	1 56	1 54	1 53	1 52	32
33	4 53	4 15	3 51	3 29	3 12	3 0	2 50	2 31	2 20	2 11	2 5	2 0	1 56	1 54	1 53	1 53	33
34	5 0	4 21	3 56	3 34	3 17	3 4	2 53	2 34	2 22	2 13	2 7	2 1	1 57	1 55	1 54	1 53	34
35	5 7	4 27	4 1	3 38	3 21	3 7	2 56	2 37	2 24	2 15	2 8	2 2	1 58	1 56	1 54	1 53	35
36	5 13	4 33	4 6	3 43	3 25	3 11	2 59	2 40	2 26	2 17	2 10	2 4	1 59	1 56	1 54	1 53	36
37	5 20	4 39	4 11	3 48	3 29	3 15	3 2	2 43	2 28	2 19	2 11	2 5	2 0	1 57	1 55	1 54	37
38	5 27	4 45	4 16	3 52	3 33	3 18	3 5	2 46	2 31	2 21	2 13	2 6	2 1	1 58	1 56	1 54	38
39	5 34	4 51	4 21	3 57	3 37	3 22	3 8	2 49	2 33	2 22	2 14	2 7	2 2	1 58	1 56	1 55	39
40	5 40	4 56	4 26	4 1	3 41	3 25	3 11	2 51	2 35	2 24	2 16	2 9	2 3	1 59	1 57	1 55	40
41	5 47	5 2	4 31	4 5	3 45	3 29	3 14	2 54	2 38	2 26	2 17	2 10	2 4	2 0	1 57	1 55	41
42	5 53	5 7	4 36	4 9	3 49	3 32	3 17	2 56	2 40	2 28	2 19	2 11	2 5	2 1	1 58	1 56	42
43	6 0	5 13	4 41	4 14	3 53	3 36	3 20	2 59	2 42	2 30	2 20	2 12	2 6	2 2	1 59	1 57	43
44	6 6	5 19	4 46	4 18	3 57	3 39	3 23	3 1	2 44	2 32	2 22	2 13	2 7	2 3	2 0	1 58	44
46	6 18	5 29	4 55	4 26	4 4	3 46	3 29	3 6	2 48	2 35	2 25	2 16	2 9	2 5	2 2	1 59	46
48	6 29	5 39	5 4	4 34	4 11	3 52	3 35	3 11	2 52	2 39	2 28	2 18	2 11	2 7	2 3	2 0	48
50	6 40	5 48	5 12	4 41	4 17	3 58	3 41	3 15	2 56	2 42	2 31	2 21	2 13	2 9	2 5	2 2	50
52	6 51	5 57	5 20	4 48	4 23	4 2	3 47	3 19	2 59	2 45	2 34	2 24	2 16	2 10	2 6	2 3	52
54	7 1	6 6	5 28	4 55	4 29	4 8	3 52	3 23	3 3	2 48	2 36	2 27	2 18	2 12	2 8	2 4	54
56	7 10	6 15	5 35	5 1	4 35	4 14	3 57	3 27	3 7	2 51	2 39	2 29	2 20	2 14	2 9	2 5	56
58	7 19	6 23	5 42	5 7	4 40	4 19	4 2	3 31	3 10	2 54	2 42	2 31	2 22	2 16	2 11	2 6	58
60	7 28	6 31	5 48	5 12	4 45	4 24	4 6	3 35	3 13	2 57	2 44	2 33	2 24	2 17	2 12	2 7	60
62	7 36	6 38	5 54	5 17	4 50	4 29	4 10	3 38	3 16	2 59	2 46	2 35	2 26	2 19	2 13	2 8	62
64	7 44	6 45	6 0	5 22	4 55	4 33	4 14	3 42	3 19	3 2	2 48	2 37	2 28	2 20	2 14	2 9	64
66	7 51	6 51	6 5	5 27	5 0	4 37	4 18	3 45	3 22	3 4	2 50	2 39	2 30	2 22	2 15		66
68	7 58	6 56	6 10	5 32	5 4	4 41	4 21	3 48	3 25	3 6	2 51	2 40	2 31	2 23			68
70	8 4	7 1	6 15	5 36	5 8	4 44	4 23	3 50	3 27	3 8	2 53	2 41	2 32				70
72	8 10	7 5	6 19	5 40	5 11	4 47	4 25	3 52	3 29	3 9	2 53	2 42					72
74	8 15	7 9	6 23	5 43	5 14	4 49	4 27	3 54	3 30	3 10	2 54						74
76	8 19	7 13	6 26	5 46	5 17	4 51	4 29	3 56	3 31	3 11							76
78	8 22	7 16	6 29	5 49	5 19	4 53	4 31	3 57	3 32								78
80	8 25	7 19	6 31	5 52	5 21	4 55	4 33	3 58									80
82	8 28	7 22	6 33	5 54	5 23	4 57	4 35										82
84	8 30	7 24	6 35	5 56	5 25												84
86	8 32	7 26	6 37														86
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 88°.

☽ App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	86°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′	′ ″	′ ″	°
6	4 40	4 54	5 8	5 22	5 48	6 13	6 36	6 57	7 16	7 34	7 49	8 2	8 13	8 21	8 27	8 32	6
7	4 4	4 16	4 28	4 40	5 3	5 25	5 45	6 4	6 21	6 36	6 49	7 0	7 9	7 16	7 22	7 27	7
8	3 41	3 52	4 3	4 13	4 33	4 52	5 10	5 26	5 40	5 53	6 5	6 15	6 23	6 29	6 34	6 37	8
9	3 22	3 31	3 41	3 50	4 8	4 24	4 39	4 53	5 5	5 16	5 26	5 35	5 43	5 49	5 54		9
10	3 6	3 14	3 22	3 30	3 46	4 1	4 15	4 27	4 38	4 49	4 58	5 7	5 14	5 19	5 23		10
11	2 54	3 2	3 9	3 16	3 30	3 43	3 56	4 7	4 17	4 27	4 36	4 43	4 49	4 53	4 57		11
12	2 44	2 51	2 58	3 4	3 16	3 28	3 40	3 50	4 0	4 8	4 16	4 23	4 28	4 32	4 36		12
13	2 35	2 41	2 47	2 53	3 4	3 15	3 26	3 35	3 44	3 52	3 59	4 5	4 10	4 13			13
14	2 27	2 33	2 38	2 44	2 54	3 4	3 14	3 22	3 30	3 37	3 44	3 50	3 54	3 57			14
15	2 22	2 27	2 32	2 36	2 46	2 55	3 4	3 11	3 18	3 25	3 31	3 37	3 41	3 44			15
16	2 17	2 21	2 26	2 30	2 39	2 47	2 55	3 2	3 9	3 15	3 21	3 26	3 30	3 33			16
17	2 12	2 16	2 21	2 25	2 33	2 40	2 47	2 54	3 0	3 6	3 12	3 16	3 19				17
18	2 8	2 12	2 16	2 20	2 27	2 34	2 41	2 47	2 53	2 58	3 3	3 7	3 10				18
19	2 5	2 8	2 12	2 16	2 22	2 29	2 35	2 41	2 47	2 52	2 56	2 59	3 2				19
20	2 3	2 6	2 9	2 12	2 18	2 24	2 30	2 35	2 41	2 46	2 49	2 52	2 54				20
21	2 1	2 3	2 6	2 8	2 14	2 19	2 25	2 30	2 35	2 40	2 43	2 46					21
22	1 59	2 1	2 3	2 5	2 10	2 15	2 20	2 25	2 30	2 35	2 38	2 41					22
23	1 57	1 59	2 1	2 3	2 7	2 12	2 16	2 21	2 26	2 30	2 33	2 36					23
24	1 56	1 57	1 59	2 1	2 5	2 9	2 13	2 17	2 22	2 26	2 29	2 31					24
25	1 55	1 56	1 57	1 59	2 3	2 6	2 10	2 14	2 18	2 22	2 25						25
26	1 54	1 55	1 56	1 58	2 1	2 4	2 8	2 12	2 15	2 18	2 21						26
27	1 53	1 54	1 55	1 57	2 0	2 3	2 6	2 10	2 13	2 15	2 17						27
28	1 53	1 54	1 55	1 56	1 58	2 1	2 4	2 8	2 11	2 13	2 14						28
29	1 52	1 53	1 54	1 55	1 57	2 0	2 3	2 6	2 8	2 10							29
30	1 52	1 53	1 53	1 54	1 56	1 59	2 2	2 4	2 6	2 8							30
31	1 52	1 52	1 52	1 53	1 55	1 58	2 0	2 2	2 4	2 5							31
32	1 51	1 52	1 52	1 53	1 55	1 57	1 59	2 1	2 2	2 3							32
33	1 52	1 51	1 51	1 52	1 54	1 56	1 58	1 59	2 0								33
34	1 52	1 51	1 51	1 52	1 53	1 55	1 57	1 58	1 59								34
35	1 52	1 51	1 51	1 51	1 52	1 54	1 56	1 57	1 57								35
36	1 53	1 52	1 51	1 51	1 52	1 53	1 55	1 56	1 56								36
37	1 53	1 52	1 51	1 51	1 51	1 52	1 54	1 55									37
38	1 53	1 52	1 51	1 50	1 51	1 52	1 53	1 54									38
39	1 54	1 52	1 51	1 50	1 51	1 52	1 52	1 53									39
40	1 54	1 53	1 52	1 51	1 50	1 51	1 52	1 52									40
41	1 54	1 53	1 52	1 51	1 50	1 51	1 51										41
42	1 54	1 53	1 52	1 51	1 50	1 51	1 51										42
43	1 55	1 54	1 53	1 52	1 51	1 51	1 51										43
44	1 56	1 54	1 53	1 52	1 51	1 50	1 50										44
46	1 57	1 55	1 53	1 52	1 51	1 50											46
48	1 58	1 56	1 54	1 53	1 51	1 50											48
50	1 59	1 57	1 55	1 53	1 51												50
52	2 0	1 58	1 55	1 53	1 52												
54	2 1	1 58	1 56	1 54													
56	2 2	1 59	1 56	1 54													
58	2 3	1 59	1 56														
60	2 3	1 59															
62	2 4																
64																	
66																	
68																	
70																	
72																	
74																	
76																	
78																	
80																	
82																	
84																	
86																	
	32°	34°	36°	38°	42°	46°	50°	54°	58°	62°	66°						

Table P. Effect of Sun's Par.

To be subtracted from the third Correction.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	1	1	1	1	1	1	1	0	0	
10	2	1	1	1	1	1	1	1	1	0
15	2	2	2	2	2	2	2	2	2	
20	3	3	3	3	3	3	3	3		
25	4	4	4	4	4	4	4	4		
30	4	4	4	4	4	4	4			
35	5	5	5	5	5	5	5			
40	6	6	6	6	6					
45	6	6	6	6	6					
50	7	7	7	7	7					
55	7	7	7	7	7					
60	8	8	8	8						
65	8	8	8							
70	8	8	8							
75	9	9								
80	9	9								
90	9									

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 92°.

D's App. Alt.	Apparent Altitude of the Sun, Star or Planet.																D's App. Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	1 59	2 1	2 3	2 6	2 10	2 15	2 21	2 34	2 48	3 3	3 18	3 33	3 48	4 3	4 18	4 33	6
7	2 1	1 59	2 1	2 3	2 5	2 9	2 13	2 22	2 33	2 45	2 58	3 11	3 24	3 36	3 48	4 0	7
8	2 4	2 1	1 59	2 0	2 2	2 4	2 7	2 14	2 23	2 33	2 44	2 55	3 5	3 16	3 26	3 37	8
9	2 8	2 4	2 1	1 59	2 0	2 2	2 4	2 9	2 16	2 24	2 33	2 42	2 51	3 1	3 10	3 19	9
10	2 13	2 7	2 3	2 1	1 59	2 0	2 2	2 6	2 11	2 17	2 24	2 32	2 40	2 48	2 57	3 5	10
11	2 19	2 11	2 6	2 3	2 1	1 59	2 0	2 3	2 7	2 12	2 18	2 24	2 31	2 39	2 46	2 54	11
12	2 25	2 16	2 10	2 6	2 3	2 1	1 59	2 1	2 4	2 8	2 13	2 18	2 24	2 31	2 37	2 44	12
13	2 32	2 21	2 14	2 9	2 5	2 2	2 0	2 0	2 2	2 5	2 9	2 14	2 19	2 24	2 30	2 36	13
14	2 39	2 27	2 18	2 12	2 7	2 4	2 2	1 59	2 1	2 3	2 6	2 10	2 14	2 19	2 24	2 29	14
15	2 46	2 32	2 22	2 15	2 10	2 6	2 3	2 0	2 0	2 1	2 4	2 7	2 10	2 15	2 19	2 24	15
16	2 53	2 38	2 27	2 19	2 13	2 8	2 5	2 1	1 59	2 0	2 2	2 4	2 7	2 11	2 15	2 19	16
17	3 0	2 44	2 32	2 23	2 16	2 11	2 7	2 3	2 0	1 59	2 1	2 3	2 5	2 8	2 12	2 15	17
18	3 8	2 50	2 37	2 27	2 19	2 14	2 9	2 4	2 1	1 59	2 0	2 2	2 4	2 6	2 9	2 12	18
19	3 16	2 56	2 42	2 31	2 22	2 16	2 11	2 6	2 2	2 0	2 0	2 1	2 2	2 4	2 7	2 10	19
20	3 23	3 2	2 48	2 36	2 26	2 19	2 14	2 8	2 3	2 0	1 59	2 0	2 1	2 3	2 5	2 8	20
21	3 31	3 9	2 54	2 41	2 30	2 23	2 17	2 10	2 5	2 1	1 59	1 59	2 0	2 2	2 4	2 6	21
22	3 38	3 15	2 59	2 45	2 34	2 26	2 20	2 12	2 6	2 2	2 0	1 59	2 0	2 1	2 2	2 4	22
23	3 46	3 22	3 4	2 50	2 38	2 30	2 23	2 14	2 8	2 3	2 0	1 59	1 59	2 0	2 1	2 2	23
24	3 53	3 28	3 9	2 54	2 42	2 34	2 27	2 16	2 9	2 4	2 1	2 0	1 59	1 59	2 0	2 1	24
25	4 1	3 34	3 15	2 59	2 46	2 37	2 30	2 19	2 11	2 5	2 2	2 0	1 59	1 59	2 0	2 0	25
26	4 9	3 40	3 20	3 3	2 50	2 41	2 33	2 22	2 13	2 7	2 4	2 1	1 59	1 59	1 59	2 0	26
27	4 17	3 46	3 26	3 8	2 55	2 45	2 36	2 24	2 15	2 9	2 5	2 2	2 0	1 59	1 59	2 0	27
28	4 24	3 52	3 31	3 13	2 59	2 48	2 39	2 27	2 17	2 11	2 6	2 2	2 0	1 59	1 59	1 59	28
29	4 31	3 58	3 36	3 18	3 3	2 52	2 43	2 29	2 19	2 12	2 7	2 3	2 1	2 0	1 59	1 59	29
30	4 38	4 4	3 41	3 22	3 7	2 56	2 46	2 32	2 21	2 13	2 8	2 4	2 1	2 0	1 59	1 59	30
31	4 46	4 10	3 47	3 27	3 12	3 0	2 50	2 35	2 23	2 15	2 9	2 5	2 2	2 0	1 59	1 59	31
32	4 53	4 16	3 52	3 32	3 16	3 4	2 53	2 37	2 25	2 16	2 11	2 7	2 3	2 1	2 0	1 59	32
33	5 0	4 22	3 58	3 37	3 20	3 8	2 57	2 40	2 27	2 18	2 12	2 8	2 4	2 1	2 0	1 59	33
34	5 7	4 28	4 3	3 41	3 24	3 11	3 0	2 42	2 29	2 20	2 14	2 9	2 5	2 2	2 1	2 0	34
35	5 14	4 34	4 8	3 46	3 28	3 15	3 3	2 45	2 31	2 22	2 15	2 10	2 6	2 3	2 1	2 0	35
36	5 21	4 40	4 13	3 50	3 32	3 18	3 6	2 47	2 33	2 24	2 17	2 11	2 7	2 4	2 2	2 1	36
37	5 28	4 46	4 18	3 55	3 36	3 22	3 9	2 50	2 36	2 25	2 18	2 12	2 8	2 5	2 3	2 1	37
38	5 34	4 52	4 23	4 0	3 40	3 25	3 12	2 53	2 38	2 27	2 20	2 14	2 9	2 6	2 4	2 2	38
39	5 41	4 58	4 28	4 4	3 44	3 29	3 15	2 55	2 40	2 29	2 21	2 15	2 10	2 7	2 4	2 2	39
40	5 47	5 3	4 33	4 8	3 48	3 32	3 18	2 58	2 42	2 31	2 22	2 16	2 11	2 7	2 5	2 3	40
41	5 54	5 9	4 38	4 12	3 52	3 35	3 21	3 0	2 45	2 33	2 24	2 17	2 12	2 8	2 5	2 3	41
42	6 0	5 14	4 43	4 16	3 55	3 39	3 24	3 2	2 47	2 34	2 25	2 18	2 13	2 9	2 6	2 4	42
43	6 7	5 20	4 48	4 21	3 59	3 42	3 27	3 5	2 49	2 36	2 27	2 20	2 14	2 10	2 7	2 4	43
44	6 13	5 25	4 53	4 25	4 3	3 46	3 30	3 8	2 51	2 38	2 28	2 21	2 15	2 11	2 8	2 5	44
45	6 19	5 31	4 58	4 29	4 7	3 49	3 33	3 11	2 53	2 40	2 30	2 22	2 16	2 12	2 8	2 5	45
46	6 25	5 36	5 2	4 33	4 10	3 52	3 36	3 13	2 55	2 42	2 31	2 24	2 18	2 13	2 9	2 6	46
47	6 31	5 41	5 7	4 37	4 13	3 55	3 39	3 16	2 57	2 44	2 33	2 25	2 19	2 14	2 10	2 7	47
48	6 37	5 46	5 11	4 41	4 17	3 59	3 42	3 18	2 59	2 46	2 35	2 27	2 20	2 15	2 11	2 8	48
50	6 47	5 56	5 19	4 48	4 24	4 5	3 48	3 22	3 4	2 49	2 37	2 29	2 22	2 16	2 12	2 9	50
52	6 57	6 5	5 27	4 55	4 30	4 11	3 53	3 26	3 8	2 53	2 41	2 32	2 24	2 18	2 13	2 10	52
54	7 7	6 14	5 35	5 2	4 36	4 16	3 58	3 30	3 11	2 56	2 44	2 34	2 26	2 20	2 15	2 11	54
56	7 17	6 23	5 42	5 9	4 42	4 21	4 3	3 34	3 14	2 59	2 47	2 37	2 29	2 22	2 16	2 12	56
58	7 27	6 31	5 49	5 15	4 47	4 26	4 8	3 38	3 17	3 2	2 49	2 39	2 31	2 24	2 18	2 13	58
60	7 36	6 39	5 56	5 21	4 53	4 31	4 13	3 42	3 20	3 5	2 52	2 41	2 32	2 25	2 20	2 14	60
62	7 45	6 46	6 2	5 26	4 58	4 36	4 17	3 46	3 23	3 8	2 54	2 43	2 34	2 26	2 21		62
64	7 53	6 53	6 8	5 31	5 3	4 41	4 21	3 50	3 26	3 10	2 56	2 44	2 35	2 27			64
66	8 1	6 59	6 13	5 36	5 8	4 45	4 25	3 53	3 29	3 12	2 57	2 45	2 37				66
68	8 8	7 5	6 18	5 41	5 12	4 49	4 28	3 56	3 32	3 14	2 58	2 46					68
70	8 14	7 10	6 23	5 45	5 16	4 52	4 31	3 58	3 34	3 15	2 59						70
72	8 20	7 15	6 28	5 49	5 19	4 55	4 33	4 0	3 35	3 16							72
74	8 25	7 19	6 31	5 53	5 22	4 57	4 35	4 1	3 36								74
76	8 29	7 23	6 34	5 56	5 25	4 59	4 37	4 2									76
78	8 32	7 26	6 37	5 58	5 27	5 1	4 39										78
80	8 34	7 28	6 39	6 0	5 29												80
82	8 36	7 30	6 41														82
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 92°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	32°	34°	36°	38°	40°	42°	46°	50°	54°	58°	62°	66°	70°	74°	78°	82°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	4 47	5 2	5 16	5 30	5 44	5 57	6 21	6 44	7 5	7 24	7 42	7 59	8 12	8 22	8 30	8 36	6
7	4 12	4 24	4 36	4 48	5 0	5 11	5 33	5 53	6 12	6 29	6 44	6 58	7 10	7 18	7 25	7 30	7
8	3 48	3 59	4 10	4 20	4 30	4 40	4 59	5 17	5 33	5 48	6 1	6 13	6 23	6 31	6 37	6 41	8
9	3 29	3 38	3 48	3 57	4 6	4 14	4 30	4 45	5 0	5 13	5 25	5 35	5 44	5 52	5 58		9
10	3 13	3 21	3 30	3 38	3 45	3 52	4 8	4 22	4 34	4 46	4 57	5 7	5 15	5 22	5 27		10
11	3 1	3 8	3 16	3 22	3 29	3 36	3 50	4 3	4 14	4 24	4 34	4 43	4 51	4 57	5 2		11
12	2 51	2 57	3 4	3 10	3 17	3 23	3 35	3 47	3 57	4 6	4 15	4 23	4 30	4 36	4 41		12
13	2 42	2 47	2 53	2 59	3 6	3 12	3 23	3 33	3 42	3 51	4 0	4 7	4 13	4 17			13
14	2 34	2 39	2 44	2 50	2 56	3 2	3 12	3 21	3 30	3 38	3 46	3 52	3 57	4 1			14
15	2 28	2 33	2 38	2 43	2 48	2 53	3 2	3 11	3 19	3 26	3 33	3 39	3 44	3 49			15
16	2 23	2 28	2 32	2 37	2 42	2 46	2 54	3 2	3 9	3 16	3 22	3 28	3 33	3 38			16
17	2 19	2 23	2 27	2 32	2 36	2 40	2 47	2 54	3 1	3 7	3 13	3 19	3 24				17
18	2 16	2 19	2 23	2 27	2 31	2 34	2 41	2 48	2 54	3 0	3 6	3 11	3 15				18
19	2 13	2 16	2 19	2 23	2 26	2 29	2 36	2 42	2 48	2 54	2 59	3 4	3 7				19
20	2 10	2 13	2 16	2 19	2 22	2 25	2 31	2 37	2 43	2 48	2 53	2 57	3 0				20
21	2 8	2 10	2 13	2 16	2 18	2 21	2 26	2 32	2 38	2 43	2 47	2 51					21
22	2 6	2 8	2 10	2 13	2 15	2 17	2 22	2 28	2 33	2 38	2 42	2 45					22
23	2 4	2 6	2 8	2 10	2 12	2 14	2 19	2 24	2 29	2 34	2 38	2 41					23
24	2 2	2 4	2 6	2 8	2 10	2 12	2 16	2 21	2 26	2 30	2 34	2 38					24
25	2 1	2 3	2 4	2 6	2 8	2 10	2 14	2 18	2 22	2 26	2 30						25
26	2 1	2 2	2 3	2 5	2 6	2 8	2 12	2 15	2 19	2 23	2 26						26
27	2 0	2 1	2 2	2 4	2 5	2 7	2 10	2 13	2 16	2 20	2 23						27
28	1 59	2 0	2 1	2 3	2 4	2 6	2 8	2 11	2 14	2 17	2 20						28
29	1 59	1 59	2 0	2 2	2 3	2 5	2 7	2 10	2 12	2 15							29
30	1 59	1 59	2 0	2 1	2 2	2 4	2 6	2 9	2 11	2 13							30
31	1 59	1 59	1 59	2 0	2 1	2 3	2 5	2 7	2 9	2 11							31
32	1 59	1 59	1 59	2 0	2 1	2 2	2 4	2 6	2 7	2 9							32
33	1 59	1 59	1 59	1 59	2 0	2 1	2 3	2 5	2 6								33
34	1 59	1 58	1 59	1 59	2 0	2 1	2 2	2 4	2 5								34
35	1 59	1 58	1 59	1 59	2 0	2 0	2 1	2 3	2 4								35
36	2 0	1 59	1 59	1 59	2 0	2 0	2 1	2 2	2 3								36
37	2 0	1 59	1 59	1 58	1 59	1 59	2 0	2 1									37
38	2 0	1 59	1 59	1 58	1 59	1 59	2 0	2 1									38
39	2 1	2 0	1 59	1 58	1 58	1 59	1 59	2 0									39
40	2 1	2 0	1 59	1 58	1 58	1 58	1 59	2 0									40
41	2 1	2 0	1 59	1 59	1 58	1 58	1 58										41
42	2 2	2 0	1 59	1 59	1 58	1 58	1 58										42
43	2 2	2 1	2 0	1 59	1 58	1 58	1 58										43
44	2 3	2 1	2 0	1 59	1 58	1 58	1 57										44
45	2 3	2 2	2 1	2 0	1 59	1 58											45
46	2 4	2 2	2 1	2 0	1 59	1 58											46
47	2 4	2 2	2 1	2 0	1 59	1 58											47
48	2 5	2 3	2 2	2 1	1 59	1 59											
50	2 6	2 4	2 2	2 1	2 0												
52	2 7	2 5	2 3	2 1													
54	2 8	2 5	2 3														
56	2 9	2 5															
58	2 10																
60																	
62																	
64																	
66																	
68																	
70																	
72																	
74																	
76																	
78																	
80																	
82																	
	32°	34°	36°	38°	40°	42°	46°	50°	54°	58°	62°						

Table P. Effect of Sun's Par.

To be subtracted from the third Correction.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	1	1	1	1	1	1	1	1	1	
10	2	2	2	2	2	2	2	2	2	0
15	2	2	2	2	3	3	3	3		
20	3	3	3	3	3	3	3	3		
25	4	4	4	4	4	4	4			
30	4	4	5	5	5	5	5			
35	5	5	5	5	5	5				
40	6	6	6	6	6	6				
45	6	6	6	7	7					
50	7	7	7	7	7					
55	7	7	7	8						
60	8	8	8	8						
65	8	8	8							
70	9	8	8							
75	9	9								
80	9	9								
90										

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 96°.

☽'s App. Alt.	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	☽'s App. Alt.
	Apparent Altitude of the Sun, Star or Planet.																
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	2 6	2 8	2 10	2 13	2 17	2 22	2 28	2 41	2 55	3 10	3 26	3 41	3 56	4 11	4 26	4 41	6
7	2 9	2 6	2 8	2 10	2 12	2 16	2 20	2 29	2 40	2 52	3 5	3 18	3 31	3 43	3 56	4 8	7
8	2 12	2 8	2 6	2 7	2 9	2 12	2 15	2 22	2 31	2 40	2 51	3 2	3 13	3 24	3 35	3 45	8
9	2 16	2 11	2 8	2 6	2 7	2 9	2 12	2 17	2 24	2 31	2 40	2 49	2 59	3 8	3 18	3 27	9
10	2 20	2 14	2 10	2 8	2 6	2 7	2 9	2 13	2 18	2 24	2 32	2 40	2 48	2 56	3 4	3 12	10
11	2 26	2 18	2 13	2 10	2 7	2 6	2 7	2 10	2 14	2 19	2 25	2 32	2 39	2 46	2 53	3 1	11
12	2 32	2 23	2 17	2 13	2 9	2 7	2 6	2 8	2 11	2 15	2 20	2 26	2 32	2 38	2 45	2 52	12
13	2 39	2 28	2 21	2 16	2 12	2 9	2 7	2 7	2 9	2 12	2 16	2 21	2 26	2 32	2 38	2 44	13
14	2 46	2 33	2 25	2 19	2 14	2 11	2 9	2 6	2 8	2 10	2 13	2 18	2 22	2 27	2 32	2 37	14
15	2 53	2 39	2 29	2 22	2 17	2 14	2 11	2 7	2 7	2 9	2 11	2 15	2 19	2 23	2 28	2 32	15
16	3 1	2 45	2 34	2 26	2 20	2 16	2 13	2 8	2 5	2 8	2 10	2 13	2 16	2 20	2 24	2 28	16
17	3 8	2 51	2 39	2 30	2 23	2 19	2 15	2 9	2 7	2 7	2 9	2 11	2 14	2 17	2 21	2 24	17
18	3 15	2 57	2 44	2 34	2 26	2 21	2 17	2 11	2 8	2 6	2 8	2 10	2 12	2 15	2 18	2 21	18
19	3 23	3 3	2 49	2 38	2 30	2 24	2 19	2 13	2 9	2 7	2 7	2 8	2 10	2 13	2 15	2 18	19
20	3 30	3 9	2 54	2 43	2 34	2 27	2 22	2 15	2 11	2 8	2 6	2 7	2 9	2 11	2 13	2 15	20
21	3 38	3 16	3 0	2 48	2 37	2 30	2 25	2 17	2 12	2 9	2 7	2 7	2 8	2 9	2 11	2 13	21
22	3 46	3 22	3 5	2 52	2 41	2 33	2 28	2 19	2 14	2 10	2 8	2 6	2 7	2 8	2 10	2 12	22
23	3 54	3 28	3 11	2 57	2 45	2 37	2 31	2 21	2 15	2 11	2 8	2 6	2 6	2 7	2 9	2 11	23
24	4 1	3 34	3 16	3 1	2 49	2 41	2 35	2 23	2 17	2 12	2 9	2 7	2 6	2 7	2 8	2 10	24
25	4 9	3 41	3 22	3 6	2 53	2 45	2 38	2 26	2 19	2 14	2 11	2 8	2 6	2 7	2 8	2 9	25
26	4 16	3 47	3 27	3 11	2 57	2 48	2 41	2 29	2 21	2 16	2 12	2 9	2 7	2 6	2 7	2 8	26
27	4 24	3 53	3 33	3 15	3 1	2 52	2 44	2 31	2 23	2 17	2 13	2 10	2 8	2 6	2 6	2 7	27
28	4 31	4 0	3 38	3 20	3 6	2 55	2 47	2 34	2 24	2 18	2 14	2 11	2 9	2 7	2 6	2 7	28
29	4 39	4 6	3 44	3 25	3 10	2 59	2 50	2 36	2 26	2 20	2 15	2 12	2 10	2 8	2 7	2 6	29
30	4 46	4 12	3 49	3 29	3 14	3 3	2 53	2 38	2 28	2 21	2 16	2 13	2 10	2 8	2 7	2 6	30
31	4 53	4 18	3 55	3 31	3 18	3 7	2 57	2 41	2 30	2 23	2 18	2 14	2 11	2 9	2 8	2 7	31
32	5 0	4 24	4 0	3 39	3 23	3 11	3 1	2 44	2 32	2 25	2 19	2 15	2 12	2 9	2 8	2 7	32
33	5 7	4 30	4 5	3 44	3 27	3 15	3 4	2 46	2 34	2 26	2 20	2 16	2 13	2 10	2 8	2 7	33
34	5 14	4 36	4 11	3 49	3 32	3 19	3 7	2 48	2 36	2 28	2 21	2 17	2 14	2 11	2 9	2 8	34
35	5 21	4 42	4 16	3 54	3 36	3 23	3 11	2 51	2 38	2 30	2 23	2 18	2 15	2 12	2 10	2 8	35
36	5 28	4 48	4 21	3 59	3 40	3 26	3 14	2 54	2 40	2 32	2 25	2 20	2 16	2 13	2 11	2 9	36
37	5 35	4 54	4 26	4 3	3 44	3 29	3 17	2 57	2 43	2 33	2 26	2 21	2 17	2 14	2 11	2 9	37
38	5 42	5 0	4 31	4 8	3 48	3 33	3 20	2 59	2 45	2 35	2 27	2 22	2 18	2 15	2 12	2 10	38
39	5 49	5 6	4 36	4 12	3 52	3 36	3 23	3 2	2 47	2 37	2 29	2 23	2 19	2 16	2 13	2 11	39
40	5 55	5 12	4 41	4 16	3 56	3 40	3 26	3 5	2 50	2 39	2 30	2 24	2 20	2 16	2 13	2 11	40
41	6 2	5 18	4 46	4 20	4 0	3 44	3 30	3 7	2 52	2 41	2 32	2 25	2 21	2 17	2 14	2 12	41
42	6 8	5 23	4 51	4 24	4 4	3 47	3 33	3 10	2 54	2 43	2 34	2 27	2 22	2 18	2 15	2 13	42
43	6 14	5 29	4 56	4 29	4 8	3 51	3 36	3 13	2 57	2 45	2 35	2 28	2 23	2 19	2 16	2 13	43
44	6 20	5 34	5 1	4 33	4 11	3 54	3 39	3 16	2 59	2 47	2 37	2 29	2 24	2 20	2 17	2 14	44
45	6 26	5 39	5 6	4 37	4 14	3 57	3 42	3 19	3 1	2 48	2 38	2 30	2 25	2 21	2 17	2 14	45
46	6 32	5 44	5 10	4 41	4 18	4 0	3 45	3 21	3 3	2 50	2 39	2 31	2 26	2 22	2 18	2 15	46
47	6 38	5 49	5 15	4 45	4 22	4 3	3 48	3 24	3 5	2 52	2 41	2 33	2 27	2 23	2 19	2 16	47
48	6 44	5 54	5 19	4 49	4 25	4 7	3 51	3 26	3 7	2 53	2 42	2 34	2 28	2 24	2 20	2 16	48
49	6 50	5 59	5 23	4 53	4 29	4 10	3 54	3 28	3 9	2 55	2 44	2 36	2 29	2 25	2 21	2 17	49
50	6 55	6 4	5 27	4 57	4 32	4 13	3 57	3 30	3 11	2 56	2 45	2 37	2 31	2 26	2 21	2 17	50
51	7 0	6 9	5 31	5 1	4 36	4 16	4 0	3 32	3 13	2 58	2 47	2 38	2 32	2 27	2 22	2 18	51
52	7 5	6 14	5 35	5 4	4 39	4 19	4 3	3 34	3 15	3 0	2 48	2 39	2 33	2 28	2 23	2 18	52
54	7 15	6 23	5 43	5 11	4 45	4 25	4 8	3 38	3 19	3 2	2 51	2 42	2 35	2 29	2 24	2 19	54
56	7 25	6 31	5 51	5 18	4 51	4 30	4 13	3 42	3 22	3 6	2 54	2 45	2 37	2 30	2 25	2 19	56
58	7 35	6 39	5 58	5 24	4 56	4 35	4 17	3 46	3 26	3 9	2 57	2 47	2 39	2 31	2 25		58
60	7 45	6 46	6 4	5 30	5 1	4 39	4 21	3 50	3 29	3 12	2 59	2 49	2 41	2 32			60
62	7 54	6 53	6 10	5 35	5 6	4 44	4 25	3 54	3 32	3 15	3 1	2 50	2 42				62
64	8 2	7 0	6 16	5 40	5 11	4 48	4 29	3 58	3 35	3 17	3 3	2 51					64
66	8 10	7 7	6 21	5 45	5 16	4 52	4 33	4 1	3 38	3 19	3 4						66
68	8 17	7 13	6 26	5 50	5 21	4 56	4 36	4 3	3 40	3 21							68
70	8 24	7 18	6 31	5 54	5 25	5 0	4 39	4 5	3 42								70
72	8 29	7 23	6 36	5 58	5 28	5 3	4 41	4 7									72
74	8 33	7 27	6 40	6 1	5 31	5 6	4 43										74
76	8 37	7 31	6 43	6 4	5 34												76
78	8 40	7 34	6 46														78
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 96°.

☽'s App. Alt.	*Apparent Altitude of the Sun, Star or Planet.*																☽'s App. Alt.
	32°	34°	36°	38°	40°	42°	44°	46°	50°	54°	58°	62°	66°	70°	74°	78°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	″	′ ″	′ ″	′ ″	′ ′	′ ′	′	′	°
6	4 56	5 10	5 24	5 38	5 51	6 4	6 17	6 29	6 52	7 14	7 34	7 52	8 9	8 23	8 33	8 40	6
7	4 20	4 32	4 44	4 56	5 8	5 20	5 31	5 42	6 2	6 20	6 37	6 52	7 6	7 18	7 28	7 35	7
8	3 56	4 7	4 18	4 29	4 39	4 49	4 59	5 8	5 26	5 42	5 56	6 9	6 21	6 31	6 40	6 47	8
9	3 37	3 46	3 55	4 4	4 13	4 23	4 32	4 40	4 56	5 10	5 23	5 34	5 44	5 53	6 1		9
10	3 22	3 30	3 37	3 45	3 53	4 2	4 10	4 17	4 31	4 43	4 55	5 6	5 16	5 24	5 31		10
11	3 9	3 17	3 24	3 31	3 38	3 45	3 52	3 59	4 11	4 22	4 33	4 43	4 52	5 0	5 7		11
12	2 59	3 6	3 12	3 19	3 25	3 32	3 38	3 45	3 55	4 5	4 15	4 24	4 32	4 39	4 46		12
13	2 50	2 56	3 2	3 8	3 14	3 20	3 26	3 32	3 42	3 51	4 0	4 8	4 15	4 21			13
14	2 42	2 48	2 53	2 58	3 4	3 9	3 15	3 20	3 30	3 39	3 48	3 55	4 1	4 6			14
15	2 36	2 41	2 46	2 50	2 55	3 0	3 5	3 10	3 19	3 28	3 36	3 43	3 49	3 54			15
16	2 32	2 36	2 40	2 44	2 48	2 53	2 57	3 2	3 10	3 18	3 25	3 32	3 38	3 44			16
17	2 28	2 31	2 35	2 39	2 43	2 47	2 51	2 55	3 3	3 10	3 16	3 22	3 28				17
18	2 24	2 27	2 31	2 35	2 38	2 42	2 45	2 49	2 56	3 2	3 8	3 14	3 19				18
19	2 21	2 24	2 27	2 31	2 34	2 37	2 40	2 44	2 50	2 56	3 2	3 7	3 11				19
20	2 18	2 21	2 24	2 27	2 30	2 33	2 36	2 39	2 45	2 51	2 56	3 1	3 4				20
21	2 16	2 19	2 21	2 24	2 26	2 29	2 32	2 35	2 41	2 46	2 51	2 55					21
22	2 14	2 17	2 19	2 21	2 23	2 26	2 28	2 31	2 37	2 42	2 46	2 50					22
23	2 13	2 15	2 17	2 19	2 21	2 23	2 25	2 28	2 33	2 38	2 42	2 45					23
24	2 11	2 13	2 15	2 17	2 19	2 21	2 23	2 25	2 30	2 35	2 38	2 41					24
25	2 10	2 11	2 13	2 15	2 17	2 19	2 21	2 23	2 27	2 31	2 35						25
26	2 9	2 10	2 12	2 13	2 15	2 17	2 19	2 21	2 25	2 28	2 31						26
27	2 8	2 9	2 11	2 12	2 14	2 16	2 18	2 20	2 23	2 25	2 27						27
28	2 8	2 9	2 10	2 11	2 13	2 15	2 17	2 18	2 21	2 23	2 24						28
29	2 7	2 8	2 9	2 10	2 12	2 13	2 15	2 17	2 19	2 21							29
30	2 7	2 8	2 9	2 10	2 11	2 12	2 14	2 15	2 17	2 19							30
31	2 6	2 7	2 8	2 9	2 10	2 11	2 12	2 14	2 16	2 17							31
32	2 6	2 7	2 7	2 8	2 9	2 10	2 11	2 12	2 14	2 16							32
33	2 6	2 6	2 7	2 7	2 8	2 9	2 10	2 11	2 13								33
34	2 7	2 6	2 7	2 7	2 8	2 9	2 10	2 11	2 12								34
35	2 7	2 6	2 6	2 7	2 7	2 8	2 9	2 10	2 11								35
36	2 8	2 7	2 6	2 6	2 7	2 8	2 9	2 9	2 10								36
37	2 8	2 7	2 6	2 6	2 7	2 7	2 8	2 8									37
38	2 9	2 8	2 7	2 6	2 6	2 7	2 8	2 8									38
39	2 9	2 8	2 7	2 6	2 6	2 7	2 7	2 8									39
40	2 10	2 8	2 7	2 6	2 6	2 6	2 7	2 7									40
41	2 10	2 9	2 8	2 7	2 7	2 6	2 6										41
42	2 11	2 9	2 8	2 7	2 7	2 6	2 6										42
43	2 11	2 10	2 8	2 7	2 7	2 6											43
44	2 12	2 10	2 8	2 7	2 7	2 6											44
45	2 12	2 10	2 9	2 8	2 7												45
46	2 13	2 11	2 9	2 8	2 7												46
47	2 13	2 11	2 9	2 8													47
48	2 13	2 11	2 9	2 8													
49	2 14	2 12	2 10														
50	2 14	2 12	2 10														
51	2 14	2 12															
52	2 15	2 12															
54	2 15																
56																	
58																	
60																	
62																	
64																	
66																	
68																	
70																	
72																	
74																	
76																	
78																	
	32°	34°	36°	38°	40°	42°	44°	46°	50°	54°	58°						

Table P. Effect of Sun's Par.

To be subtracted from the Third Correction.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	1	1	1	1	1	1	1	2	2	
10	2	2	2	2	2	2	2	3		
15	2	2	3	3	3	3	3	3		
20	3	3	3	4	4	4	4			
25	4	4	4	4	4	5	5			
30	5	5	5	5	5	5				
35	5	5	5	6	6	6				
40	6	6	6	6	6					
45	6	7	7	7	7					
50	7	7	7	7						
55	7	8	8	8						
60	8	8	8							
65	8	8	8							
70	9	9								
75	9	9								
80	9									
90										

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 100°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	2 13	2 15	2 18	2 21	2 25	2 31	2 37	2 49	3 3	3 18	3 33	3 48	4 4	4 19	4 34	4 49	6
7	2 16	2 13	2 15	2 17	2 20	2 24	2 29	2 38	2 49	3 1	3 13	3 25	3 38	3 50	4 3	4 10	7
8	2 19	2 15	2 13	2 14	2 16	2 19	2 23	2 31	2 39	2 49	2 59	3 10	3 21	3 32	3 43	3 54	8
9	2 23	2 18	2 15	2 13	2 14	2 16	2 19	2 25	2 32	2 40	2 48	2 58	3 7	3 16	3 26	3 35	9
10	2 28	2 22	2 18	2 15	2 13	2 14	2 16	2 21	2 26	2 33	2 40	2 48	2 56	3 4	3 13	3 21	10
11	2 33	2 26	2 21	2 17	2 15	2 13	2 14	2 18	2 22	2 27	2 33	2 40	2 47	2 54	3 2	3 10	11
12	2 40	2 30	2 24	2 20	2 17	2 14	2 13	2 16	2 19	2 23	2 28	2 34	2 40	2 46	2 53	3 0	12
13	2 47	2 35	2 28	2 23	2 19	2 16	2 14	2 14	2 17	2 20	2 24	2 29	2 34	2 40	2 45	2 51	13
14	2 54	2 40	2 32	2 26	2 21	2 18	2 16	2 13	2 15	2 18	2 21	2 25	2 30	2 35	2 39	2 44	14
15	3 1	2 46	2 36	2 29	2 24	2 21	2 18	2 14	2 14	2 16	2 19	2 22	2 26	2 30	2 34	2 39	15
16	3 8	2 52	2 41	2 33	2 27	2 23	2 20	2 16	2 13	2 15	2 17	2 20	2 23	2 26	2 30	2 35	16
17	3 15	2 58	2 46	2 37	2 30	2 25	2 22	2 17	2 14	2 14	2 16	2 18	2 21	2 24	2 27	2 31	17
18	3 23	3 4	2 51	2 41	2 33	2 28	2 24	2 19	2 15	2 13	2 15	2 17	2 19	2 22	2 25	2 28	18
19	3 30	3 11	2 56	2 45	2 37	2 31	2 26	2 20	2 16	2 14	2 14	2 16	2 17	2 20	2 22	2 25	19
20	3 38	3 17	3 2	2 50	2 41	2 34	2 29	2 22	2 18	2 15	2 13	2 15	2 16	2 18	2 20	2 23	20
21	3 45	3 24	3 8	2 54	2 45	2 38	2 32	2 24	2 19	2 16	2 14	2 14	2 15	2 17	2 19	2 21	21
22	3 53	3 30	3 13	2 59	2 49	2 41	2 35	2 26	2 21	2 18	2 15	2 13	2 14	2 16	2 18	2 20	22
23	4 1	3 36	3 19	3 4	2 53	2 45	2 38	2 28	2 23	2 19	2 16	2 13	2 13	2 15	2 17	2 19	23
24	4 9	3 42	3 24	3 9	2 58	2 49	2 42	2 31	2 24	2 20	2 17	2 14	2 13	2 14	2 16	2 18	24
25	4 16	3 49	3 30	3 14	3 2	2 53	2 45	2 33	2 26	2 21	2 18	2 15	2 14	2 14	2 15	2 17	25
26	4 24	3 55	3 35	3 19	3 6	2 56	2 48	2 36	2 28	2 23	2 19	2 16	2 14	2 14	2 15	2 16	26
27	4 31	4 2	3 41	3 24	3 11	3 0	2 51	2 38	2 30	2 24	2 20	2 17	2 15	2 14	2 14	2 15	27
28	4 39	4 8	3 46	3 28	3 15	3 4	2 54	2 40	2 32	2 25	2 21	2 18	2 16	2 15	2 14	2 15	28
29	4 46	4 14	3 52	3 33	3 19	3 7	2 58	2 43	2 34	2 26	2 22	2 19	2 17	2 15	2 14	2 14	29
30	4 54	4 20	3 57	3 38	3 23	3 11	3 1	2 45	2 36	2 28	2 24	2 21	2 18	2 16	2 15	2 14	30
31	5 1	4 26	4 3	3 42	3 27	3 15	3 5	2 48	2 38	2 30	2 25	2 22	2 19	2 17	2 15	2 14	31
32	5 8	4 33	4 8	3 47	3 31	3 18	3 8	2 51	2 40	2 32	2 27	2 23	2 20	2 17	2 16	2 15	32
33	5 16	4 39	4 14	3 52	3 36	3 22	3 11	2 54	2 42	2 33	2 28	2 24	2 21	2 18	2 16	2 15	33
34	5 23	4 45	4 19	3 57	3 40	3 26	3 15	2 56	2 44	2 35	2 29	2 25	2 22	2 19	2 17	2 16	34
35	5 30	4 51	4 24	4 2	3 44	3 30	3 18	2 59	2 46	2 37	2 31	2 26	2 23	2 20	2 18	2 16	35
36	5 37	4 57	4 29	4 7	3 48	3 34	3 22	3 2	2 49	2 39	2 32	2 28	2 24	2 20	2 18	2 17	36
37	5 44	5 3	4 35	4 12	3 52	3 38	3 25	3 5	2 51	2 41	2 34	2 29	2 25	2 21	2 19	2 18	37
38	5 51	5 9	4 40	4 16	3 56	3 41	3 28	3 8	2 54	2 43	2 36	2 30	2 26	2 22	2 20	2 18	38
39	5 58	5 15	4 45	4 21	4 0	3 45	3 31	3 11	2 56	2 45	2 37	2 31	2 27	2 23	2 21	2 19	39
40	6 4	5 21	4 50	4 25	4 4	3 48	3 34	3 14	2 58	2 47	2 38	2 32	2 28	2 24	2 22	2 20	40
41	6 11	5 27	4 55	4 29	4 8	3 52	3 38	3 17	3 1	2 49	2 40	2 34	2 29	2 25	2 22	2 20	41
42	6 18	5 33	5 0	4 33	4 12	3 55	3 41	3 19	3 3	2 51	2 41	2 35	2 30	2 26	2 23	2 21	42
43	6 24	5 38	5 5	4 38	4 16	3 59	3 44	3 22	3 6	2 53	2 43	2 36	2 31	2 27	2 24	2 22	43
44	6 30	5 44	5 9	4 42	4 20	4 2	3 47	3 24	3 8	2 55	2 45	2 38	2 32	2 28	2 25	2 22	44
45	6 36	5 49	5 14	4 46	4 24	4 6	3 50	3 27	3 10	2 57	2 47	2 39	2 33	2 29	2 26	2 23	45
46	6 42	5 54	5 18	4 50	4 27	4 9	3 53	3 29	3 12	2 59	2 48	2 41	2 35	2 30	2 27	2 24	46
47	6 48	5 59	5 23	4 54	4 31	4 12	3 56	3 32	3 14	3 0	2 50	2 42	2 36	2 31	2 28	2 25	47
48	6 54	6 4	5 27	4 58	4 34	4 15	3 59	3 34	3 16	3 2	2 51	2 43	2 37	2 32	2 28	2 25	48
49	7 0	6 9	5 32	5 2	4 38	4 18	4 2	3 37	3 18	3 4	2 53	2 45	2 38	2 33	2 29	2 26	49
50	7 5	6 14	5 36	5 6	4 41	4 21	4 5	3 39	3 20	3 5	2 54	2 46	2 39	2 34	2 30	2 26	50
51	7 11	6 19	5 41	5 10	4 45	4 24	4 8	3 42	3 22	3 7	2 55	2 47	2 40	2 35	2 31	2 27	51
52	7 16	6 24	5 45	5 14	4 48	4 27	4 11	3 44	3 24	3 9	2 57	2 49	2 42	2 36	2 31	2 27	52
53	7 21	6 29	5 49	5 17	4 52	4 30	4 14	3 46	3 26	3 11	2 59	2 50	2 43	2 37	2 32		53
54	7 26	6 34	5 53	5 21	4 55	4 33	4 16	3 48	3 28	3 12	3 0	2 51	2 44	2 37	2 32		54
55	7 31	6 39	5 57	5 24	4 58	4 36	4 19	3 50	3 30	3 14	3 1	2 52	2 45	2 38			55
56	7 36	6 43	6 0	5 27	5 1	4 39	4 22	3 52	3 32	3 16	3 2	2 53	2 46	2 39			56
58	7 46	6 51	6 7	5 33	5 7	4 44	4 26	3 56	3 36	3 19	3 5	2 55	2 47				58
60	7 56	6 58	6 14	5 39	5 12	4 49	4 31	4 0	3 39	3 22	3 8	2 57					60
62	8 5	7 5	6 20	5 45	5 17	4 54	4 36	4 4	3 42	3 24	3 10						62
64	8 13	7 12	6 26	5 51	5 22	4 59	4 40	4 7	3 45	3 26							64
66	8 21	7 19	6 32	5 57	5 27	5 3	4 43	4 10	3 47								66
68	8 28	7 25	6 38	6 2	5 32	5 7	4 45	4 13									68
70	8 35	7 30	6 43	6 7	5 36	5 11	4 48										70
72	8 40	7 35	6 47	6 11	5 40												72
74	8 44	7 40	6 51														74
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 100°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	54°	58°	62°	66°	70°	74°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	5 4	5 19	5 34	5 48	6 2	6 15	6 28	6 41	6 53	7 4	7 25	7 46	8 5	8 20	8 33	8 44	6
7	4 29	4 41	4 54	5 6	5 18	5 30	5 41	5 52	6 3	6 13	6 32	6 50	7 6	7 19	7 30	7 40	7
8	4 5	4 16	4 27	4 38	4 48	4 58	5 8	5 17	5 26	5 35	5 52	6 7	6 20	6 32	6 43	6 52	8
9	3 45	3 55	4 5	4 15	4 24	4 32	4 41	4 49	4 57	5 4	5 19	5 33	5 45	5 56	6 7		9
10	3 30	3 39	3 47	3 55	4 3	4 11	4 19	4 26	4 33	4 40	4 54	5 6	5 16	5 26	5 36		10
11	3 18	3 26	3 33	3 40	3 47	3 54	4 1	4 8	4 15	4 21	4 33	4 44	4 54	5 3	5 12		11
12	3 7	3 14	3 21	3 27	3 34	3 40	3 47	3 53	3 59	4 4	4 15	4 25	4 34	4 43	4 52		12
13	2 58	3 4	3 10	3 16	3 22	3 28	3 34	3 40	3 46	3 51	4 0	4 9	4 17	4 25			13
14	2 50	2 56	3 1	3 7	3 12	3 18	3 23	3 29	3 34	3 39	3 48	3 56	4 4	4 10			14
15	2 44	2 49	2 54	2 59	3 4	3 9	3 14	3 19	3 24	3 28	3 37	3 45	3 52	3 59			15
16	2 39	2 44	2 48	2 52	2 57	3 2	3 7	3 11	3 15	3 19	3 27	3 35	3 42	3 49			16
17	2 35	2 39	2 43	2 47	2 51	2 56	3 0	3 4	3 8	3 12	3 19	3 26	3 33				17
18	2 31	2 35	2 38	2 42	2 46	2 50	2 54	2 58	3 1	3 5	3 12	3 18	3 24				18
19	2 28	2 31	2 34	2 38	2 42	2 45	2 49	2 52	2 55	2 59	3 5	3 11	3 16				19
20	2 25	2 28	2 31	2 35	2 38	2 41	2 44	2 47	2 50	2 54	3 0	3 5	3 10				20
21	2 23	2 26	2 29	2 32	2 35	2 38	2 40	2 43	2 46	2 49	2 55	3 0					21
22	2 22	2 24	2 27	2 29	2 32	2 35	2 37	2 40	2 43	2 45	2 50	2 55					22
23	2 21	2 23	2 25	2 27	2 29	2 32	2 34	2 37	2 40	2 42	2 46	2 50					23
24	2 20	2 22	2 23	2 25	2 27	2 29	2 32	2 35	2 37	2 39	2 43	2 46					24
25	2 19	2 20	2 21	2 23	2 25	2 27	2 30	2 32	2 34	2 36	2 40						25
26	2 18	2 19	2 20	2 21	2 23	2 25	2 28	2 30	2 32	2 34	2 37						26
27	2 17	2 18	2 19	2 20	2 22	2 24	2 26	2 28	2 30	2 32	2 34						27
28	2 16	2 17	2 18	2 19	2 21	2 23	2 24	2 26	2 28	2 30	2 31						28
29	2 15	2 16	2 17	2 18	2 20	2 22	2 23	2 25	2 26	2 28							29
30	2 15	2 16	2 17	2 18	2 19	2 21	2 22	2 24	2 25	2 26							30
31	2 14	2 15	2 16	2 17	2 18	2 20	2 21	2 22	2 23	2 24							31
32	2 14	2 15	2 16	2 17	2 18	2 19	2 20	2 21	2 22	2 23							32
33	2 15	2 15	2 15	2 16	2 17	2 18	2 19	2 20	2 21								33
34	2 15	2 15	2 15	2 16	2 17	2 18	2 19	2 19	2 20								34
35	2 15	2 15	2 15	2 15	2 16	2 17	2 18	2 18									35
36	2 16	2 15	2 15	2 15	2 16	2 17	2 17	2 18									36
37	2 17	2 16	2 15	2 15	2 16	2 16	2 17										37
38	2 17	2 16	2 15	2 15	2 16	2 16	2 17										38
39	2 18	2 17	2 16	2 16	2 16	2 16											39
40	2 18	2 17	2 16	2 16	2 16	2 16											40
41	2 19	2 18	2 17	2 16	2 16												41
42	2 19	2 18	2 17	2 16	2 16												42
43	2 20	2 18	2 17	2 16													43
44	2 20	2 19	2 17	2 16													44
45	2 21	2 19	2 17														45
46	2 21	2 19	2 17														46
47	2 22	2 19															47
48	2 22	2 19															
49	2 23																
50	2 23																
51																	
52																	
53																	
54																	
55																	
56																	
58																	
60																	
62																	
64																	
66																	
68																	
70																	
72																	
74																	
	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	54°						

Table P. Effect of Sun's Par.
To be subtracted from the Third Correction.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	75	80
	″	″	″	″	″	″	″	″	″	
5	1	1	1	2	2	2	2	2	2	
10	2	2	2	2	3	3	3	3		
15	2	3	3	3	3	4	4	4		
20	3	3	4	4	4	4	4			
25	4	4	4	5	5	5	5			
30	5	5	5	5	6	6				
35	5	5	6	6	6	6				
40	6	6	6	7	7					
45	7	7	7	7						
50	7	7	7	8						
55	8	8	8							
60	8	8	8							
65	8	9								
70	9	9								
75	9									

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 104°.

☽'s App. Alt.	*Apparent Altitude of the Sun, Star or Planet.* 6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	☽'s App. Alt.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	2 20	2 22	2 25	2 29	2 33	2 39	2 45	2 58	3 13	3 28	3 43	3 59	4 15	4 30	4 46	5 1	6
7	2 23	2 20	2 22	2 25	2 28	2 32	2 36	2 46	2 57	3 10	3 23	3 36	3 48	4 1	4 14	4 27	7
8	2 26	2 22	2 20	2 22	2 24	2 27	2 30	2 38	2 47	2 57	3 8	3 20	3 31	3 42	3 53	4 4	8
9	2 30	2 25	2 22	2 21	2 22	2 24	2 26	2 32	2 39	2 48	2 57	3 7	3 17	3 26	3 36	3 46	9
10	2 36	2 29	2 25	2 22	2 21	2 22	2 24	2 28	2 34	2 41	2 48	2 56	3 5	3 14	3 23	3 31	10
11	2 42	2 34	2 28	2 24	2 22	2 21	2 22	2 25	2 30	2 35	2 41	2 48	2 55	3 4	3 11	3 19	11
12	2 48	2 39	2 32	2 27	2 24	2 22	2 21	2 23	2 27	2 31	2 36	2 42	2 48	2 56	3 2	3 9	12
13	2 55	2 44	2 36	2 30	2 26	2 24	2 22	2 22	2 25	2 28	2 32	2 38	2 43	2 49	2 55	3 1	13
14	3 2	2 49	2 40	2 33	2 29	2 26	2 24	2 22	2 23	2 26	2 30	2 34	2 39	2 43	2 48	2 54	14
15	3 9	2 54	2 45	2 37	2 32	2 28	2 26	2 23	2 22	2 25	2 28	2 31	2 35	2 39	2 43	2 48	15
16	3 10	3 0	2 50	2 41	2 35	2 31	2 28	2 24	2 22	2 24	2 26	2 29	2 32	2 35	2 39	2 44	16
17	3 23	3 6	2 55	2 45	2 38	2 33	2 30	2 26	2 23	2 23	2 25	2 27	2 30	2 33	2 36	2 40	17
18	3 31	3 13	3 0	2 49	2 41	2 36	2 33	2 27	2 24	2 22	2 24	2 26	2 28	2 31	2 34	2 37	18
19	3 38	3 19	3 5	2 53	2 45	2 39	2 35	2 29	2 25	2 23	2 23	2 24	2 26	2 29	2 31	2 34	19
20	3 46	3 25	3 11	2 58	2 49	2 43	2 38	2 31	2 27	2 24	2 22	2 23	2 25	2 27	2 29	2 32	20
21	3 54	3 32	3 16	3 3	2 53	2 46	2 41	2 33	2 28	2 25	2 23	2 22	2 24	2 26	2 28	2 30	21
22	4 2	3 38	3 22	3 8	2 57	2 50	2 44	2 35	2 30	2 26	2 24	2 22	2 23	2 25	2 27	2 29	22
23	4 10	3 45	3 27	3 13	3 2	2 54	2 47	2 38	2 32	2 28	2 25	2 23	2 22	2 24	2 26	2 28	23
24	4 18	3 51	3 33	3 18	3 6	2 57	2 50	2 40	2 33	2 29	2 26	2 24	2 22	2 23	2 25	2 27	24
25	4 26	3 58	3 39	3 22	3 10	3 1	2 54	2 42	2 35	2 30	2 27	2 24	2 23	2 23	2 24	2 26	25
26	4 33	4 4	3 44	3 27	3 15	3 5	2 57	2 44	2 36	2 31	2 28	2 25	2 24	2 23	2 24	2 26	26
27	4 41	4 11	3 50	3 32	3 19	3 9	3 0	2 47	2 38	2 32	2 29	2 26	2 24	2 23	2 24	2 25	27
28	4 49	4 18	3 56	3 37	3 23	3 12	3 3	2 49	2 40	2 34	2 30	2 27	2 25	2 24	2 24	2 25	28
29	4 57	4 24	4 1	3 42	3 28	3 16	3 7	2 52	2 42	2 35	2 31	2 28	2 26	2 25	2 24	2 25	29
30	5 4	4 30	4 7	3 47	3 32	3 20	3 10	2 55	2 44	2 37	2 33	2 30	2 27	2 25	2 24	2 24	30
31	5 12	4 37	4 13	3 52	3 36	3 24	3 14	2 58	2 46	2 39	2 34	2 31	2 28	2 26	2 25	2 24	31
32	5 19	4 44	4 19	3 57	3 41	3 28	3 17	3 0	2 49	2 41	2 36	2 32	2 29	2 27	2 26	2 25	32
33	5 27	4 51	4 25	4 2	3 46	3 32	3 21	3 3	2 51	2 43	2 37	2 33	2 30	2 28	2 26	2 25	33
34	5 34	4 58	4 30	4 7	3 50	3 36	3 24	3 5	2 54	2 45	2 39	2 34	2 31	2 29	2 27	2 26	34
35	5 42	5 4	4 36	4 12	3 55	3 40	3 27	3 8	2 56	2 47	2 40	2 35	2 32	2 30	2 28	2 27	35
36	5 49	5 10	4 41	4 17	3 59	3 44	3 31	3 11	2 58	2 49	2 42	2 37	2 33	2 30	2 28	2 27	36
37	5 56	5 16	4 46	4 21	4 3	3 47	3 35	3 14	3 1	2 51	2 43	2 38	2 34	2 31	2 29	2 27	37
38	6 3	5 22	4 51	4 26	4 7	3 51	3 38	3 17	3 4	2 53	2 45	2 39	2 35	2 32	2 30	2 28	38
39	6 10	5 28	4 56	4 31	4 11	3 55	3 41	3 20	3 6	2 55	2 47	2 41	2 36	2 33	2 31	2 29	39
40	6 16	5 33	5 1	4 36	4 15	3 59	3 45	3 23	3 9	2 57	2 49	2 42	2 37	2 34	2 32	2 30	40
41	6 23	5 39	5 6	4 40	4 19	4 3	3 49	3 26	3 11	2 59	2 51	2 44	2 39	2 35	2 32	2 30	41
42	6 30	5 44	5 11	4 44	4 23	4 6	3 53	3 29	3 13	3 1	2 52	2 45	2 40	2 36	2 33	2 31	42
43	6 37	5 50	5 16	4 49	4 27	4 10	3 56	3 32	3 15	3 3	2 54	2 47	2 41	2 37	2 34	2 31	43
44	6 43	5 55	5 21	4 53	4 31	4 13	3 59	3 35	3 18	3 5	2 55	2 48	2 42	2 38	2 35	2 32	44
45	6 50	6 1	5 26	4 58	4 35	4 17	4 2	3 38	3 20	3 6	2 57	2 50	2 44	2 39	2 35	2 32	45
46	6 56	6 6	5 31	5 2	4 39	4 20	4 5	3 40	3 22	3 8	2 58	2 51	2 45	2 40	2 36	2 33	46
47	7 2	6 12	5 36	5 6	4 43	4 24	4 8	3 43	3 24	3 10	3 0	2 52	2 46	2 41	2 37	2 34	47
48	7 8	6 17	5 40	5 10	4 46	4 27	4 11	3 45	3 26	3 12	3 1	2 53	2 48	2 42	2 38	2 34	48
49	7 14	6 23	5 45	5 14	4 50	4 30	4 14	3 47	3 28	3 14	3 3	2 55	2 49	2 43	2 38		49
50	7 20	6 28	5 49	5 18	4 53	4 33	4 17	3 50	3 30	3 16	3 4	2 56	2 50	2 44	2 39		50
51	7 26	6 33	5 53	5 22	4 57	4 36	4 20	3 52	3 32	3 18	3 6	2 58	2 51	2 45			51
52	7 32	6 38	5 57	5 26	5 0	4 39	4 23	3 54	3 34	3 20	3 8	2 59	2 52	2 45			52
53	7 37	6 43	6 2	5 29	5 4	4 42	4 26	3 56	3 36	3 22	3 9	3 0	2 52				53
54	7 42	6 48	6 6	5 33	5 7	4 45	4 29	3 58	3 38	3 23	3 10	3 1	2 53				54
55	7 47	6 53	6 10	5 36	5 10	4 48	4 32	4 0	3 40	3 25	3 12	3 1					55
56	7 52	6 57	6 14	5 40	5 13	4 51	4 34	4 3	3 42	3 26	3 13	3 2					56
57	7 57	7 1	6 18	5 44	5 16	4 54	4 37	4 5	3 44	3 28	3 14						57
58	8 2	7 5	6 22	5 47	5 19	4 57	4 39	4 7	3 46	3 29	3 15						58
59	8 6	7 9	6 26	5 50	5 22	5 0	4 41	4 9	3 48	3 31							59
60	8 10	7 13	6 30	5 53	5 25	5 2	4 43	4 11	3 50	3 32							60
62	8 19	7 19	6 36	5 59	5 30	5 6	4 47	4 15	3 52								62
64	8 27	7 26	6 42	6 4	5 35	5 10	4 51	4 19									64
66	8 35	7 33	6 47	6 9	5 40	5 14	4 54										66
68	8 43	7 39	6 52	6 14	5 45												68
70	8 49	7 45	6 57														70
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 104°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	52°	54°	58°	62°	66°	70°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	5 16	5 31	5 45	6 0	6 14	6 28	6 41	6 54	7 6	7 18	7 29	7 40	8 0	8 19	8 35	8 49	6
7	4 42	4 56	5 8	5 20	5 31	5 42	5 53	6 4	6 15	6 26	6 37	6 47	7 4	7 19	7 33	7 46	7
8	4 16	4 28	4 39	4 49	4 59	5 9	5 19	5 28	5 38	5 47	5 57	6 6	6 21	6 34	6 46	6 57	8
9	3 55	4 5	4 15	4 25	4 34	4 43	4 52	5 0	5 8	5 16	5 24	5 32	5 46	5 58	6 9		9
10	3 40	3 49	3 58	4 7	4 15	4 23	4 31	4 38	4 45	4 52	4 59	5 6	5 18	5 30	5 40		10
11	3 27	3 35	3 43	3 51	3 58	4 5	4 12	4 19	4 26	4 32	4 38	4 44	4 55	5 6	5 16		11
12	3 16	3 23	3 30	3 37	3 44	3 51	3 58	4 4	4 10	4 17	4 23	4 28	4 38	4 47	4 56		12
13	3 7	3 13	3 20	3 26	3 33	3 39	3 45	3 51	3 56	4 2	4 7	4 12	4 22	4 30			13
14	2 59	3 5	3 11	3 17	3 23	3 29	3 34	3 39	3 44	3 49	3 54	3 59	4 8	4 15			14
15	2 53	2 58	3 4	3 9	3 15	3 20	3 25	3 29	3 34	3 38	3 43	3 47	3 56	4 3			15
16	2 48	2 53	2 58	3 3	3 8	3 12	3 17	3 21	3 25	3 29	3 33	3 37	3 45	3 52			16
17	2 44	2 49	2 53	2 58	3 2	3 6	3 10	3 14	3 17	3 21	3 25	3 29	3 36				17
18	2 41	2 45	2 49	2 53	2 57	3 1	3 4	3 8	3 11	3 15	3 18	3 22	3 29				18
19	2 38	2 41	2 45	2 49	2 53	2 56	2 59	3 3	3 6	3 9	3 12	3 16	3 22				19
20	2 35	2 38	2 42	2 45	2 49	2 52	2 55	2 58	3 1	3 4	3 7	3 10	3 16				20
21	2 33	2 36	2 39	2 42	2 45	2 48	2 51	2 54	2 57	3 0	3 3	3 5					21
22	2 31	2 34	2 36	2 39	2 42	2 45	2 47	2 50	2 53	2 56	2 59	3 1					22
23	2 30	2 32	2 34	2 37	2 39	2 42	2 44	2 47	2 50	2 53	2 55	2 57					23
24	2 29	2 31	2 33	2 35	2 37	2 40	2 42	2 44	2 47	2 50	2 52	2 54					24
25	2 28	2 29	2 31	2 33	2 35	2 38	2 40	2 42	2 44	2 47	2 49						25
26	2 27	2 28	2 30	2 32	2 34	2 36	2 38	2 40	2 42	2 44	2 46						26
27	2 26	2 27	2 29	2 31	2 32	2 34	2 36	2 38	2 40	2 41							27
28	2 26	2 27	2 28	2 30	2 31	2 33	2 35	2 36	2 38	2 39							28
29	2 25	2 26	2 27	2 29	2 30	2 32	2 33	2 34	2 36								29
30	2 25	2 26	2 27	2 28	2 29	2 31	2 32	2 33	2 34								30
31	2 24	2 25	2 26	2 27	2 28	2 30	2 31	2 32									31
32	2 24	2 25	2 26	2 27	2 28	2 29	2 30	2 31									32
33	2 24	2 24	2 25	2 26	2 27	2 28	2 29										33
34	2 25	2 24	2 25	2 26	2 27	2 27	2 28										34
35	2 26	2 25	2 25	2 26	2 26	2 27											35
36	2 26	2 25	2 25	2 26	2 26	2 27											36
37	2 26	2 25	2 25	2 26	2 26												37
38	2 27	2 26	2 26	2 26	2 26												38
39	2 27	2 26	2 26	2 26													39
40	2 28	2 27	2 26	2 26													40
41	2 28	2 27	2 26														41
42	2 29	2 27	2 26														42
43	2 29	2 27															43
44	2 30	2 28															44
45	2 30																45
46	2 31																46
47																	47
48																	
49																	
50																	
51																	
52																	
53																	
54																	
55																	
56																	
57																	
58																	
59																	
60																	
62																	
64																	
66																	
68																	
70																	
	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	52°						

Table P. Effect of Sun's Par.

To be subtracted from the Third Correction.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″		″	″	″
5	1	1	2	2	2	2	3	3		
10	2	2	2	3	3	3	4	4		
15	2	3	3	3	4	4	4	4		
20	3	4	4	4	5	5	5			
25	4	4	5	5	5	6				
30	5	5	5	6	6	6				
35	6	6	6	6	7					
40	6	6	7	7	7					
45	7	7	7	8						
50	7	8	8							
55	8	8	8							
60	8	8								
65	9	9								
70	9									

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 108°

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	2 30	2 32	2 35	2 39	2 44	2 50	2 56	3 9	3 24	3 39	3 55	4 11	4 27	4 43	4 59	5 15	6
7	2 33	2 30	2 32	2 35	2 39	2 43	2 48	2 58	3 10	3 22	3 35	3 48	4 2	4 15	4 28	4 41	7
8	2 36	2 32	2 30	2 32	2 35	2 38	2 42	2 49	2 58	3 9	3 20	3 31	3 42	3 54	4 6	4 17	8
9	2 40	2 35	2 32	2 31	2 33	2 35	2 38	2 43	2 50	2 58	3 8	3 18	3 28	3 38	3 48	3 58	9
10	2 46	2 39	2 35	2 33	2 31	2 33	2 35	2 39	2 44	2 51	2 59	3 7	3 16	3 25	3 34	3 43	10
11	2 52	2 44	2 38	2 35	2 33	2 32	2 33	2 37	2 41	2 46	2 53	3 0	3 7	3 15	3 23	3 30	11
12	2 59	2 49	2 42	2 38	2 35	2 33	2 32	2 35	2 39	2 43	2 48	2 54	3 0	3 7	3 14	3 20	12
13	3 6	2 54	2 46	2 41	2 37	2 35	2 33	2 34	2 37	2 40	2 44	2 49	2 54	3 0	3 6	3 12	13
14	3 13	2 59	2 51	2 44	2 40	2 37	2 35	2 33	2 35	2 38	2 41	2 45	2 49	2 54	2 59	3 5	14
15	3 20	3 5	2 56	2 48	2 43	2 39	2 37	2 34	2 34	2 36	2 39	2 42	2 46	2 50	2 54	2 59	15
16	3 28	3 11	3 1	2 52	2 46	2 42	2 39	2 35	2 33	2 35	2 37	2 40	2 43	2 46	2 50	2 54	16
17	3 35	3 17	3 6	2 56	2 49	2 45	2 42	2 37	2 34	2 34	2 35	2 38	2 40	2 43	2 47	2 50	17
18	3 43	3 24	3 11	3 0	2 53	2 48	2 44	2 39	2 35	2 33	2 34	2 36	2 38	2 41	2 44	2 47	18
19	3 50	3 31	3 17	3 5	2 57	2 51	2 46	2 40	2 36	2 34	2 33	2 35	2 37	2 39	2 42	2 45	19
20	3 58	3 37	3 22	3 10	3 1	2 54	2 49	2 42	2 38	2 35	2 33	2 34	2 36	2 38	2 40	2 43	20
21	4 6	3 44	3 28	3 14	3 4	2 57	2 52	2 44	2 39	2 36	2 34	2 34	2 35	2 37	2 39	2 41	21
22	4 14	3 51	3 34	3 19	3 8	3 0	2 55	2 46	2 41	2 37	2 35	2 34	2 35	2 36	2 38	2 40	22
23	4 22	3 58	3 40	3 24	3 12	3 4	2 58	2 48	2 42	2 38	2 36	2 34	2 34	2 35	2 37	2 39	23
24	4 30	4 4	3 46	3 29	3 17	3 8	3 1	2 50	2 44	2 40	2 37	2 35	2 34	2 35	2 36	2 38	24
25	4 38	4 11	3 51	3 34	3 22	3 12	3 4	2 53	2 46	2 41	2 38	2 36	2 34	2 34	2 35	2 37	25
26	4 46	4 18	3 57	3 39	3 26	3 16	3 8	2 55	2 48	2 43	2 39	2 37	2 35	2 34	2 35	2 36	26
27	4 54	4 25	4 3	3 44	3 31	3 20	3 11	2 58	2 50	2 44	2 40	2 38	2 36	2 35	2 34	2 35	27
28	5 2	4 31	4 9	3 49	3 35	3 24	3 15	3 0	2 52	2 46	2 42	2 39	2 37	2 35	2 34	2 35	28
29	5 10	4 37	4 15	3 54	3 40	3 28	3 18	3 3	2 54	2 47	2 43	2 40	2 38	2 36	2 35	2 35	29
30	5 18	4 44	4 21	3 59	3 44	3 32	3 22	3 6	2 56	2 49	2 45	2 41	2 38	2 36	2 35	2 35	30
31	5 26	4 51	4 27	4 4	3 48	3 36	3 25	3 9	2 58	2 50	2 46	2 42	2 39	2 37	2 36	2 35	31
32	5 33	4 58	4 33	4 9	3 52	3 40	3 28	3 11	3 0	2 52	2 47	2 43	2 40	2 38	2 37	2 36	32
33	5 41	5 5	4 38	4 14	3 57	3 44	3 32	3 14	3 2	2 54	2 48	2 44	2 41	2 39	2 37	2 36	33
34	5 48	5 11	4 43	4 19	4 1	3 47	3 36	3 17	3 5	2 56	2 50	2 45	2 42	2 40	2 38	2 37	34
35	5 56	5 18	4 49	4 24	4 5	3 51	3 39	3 20	3 7	2 58	2 51	2 46	2 43	2 41	2 39	2 37	35
36	6 3	5 24	4 55	4 29	4 10	3 55	3 42	3 23	3 9	3 0	2 53	2 48	2 44	2 42	2 40	2 38	36
37	6 10	5 30	5 0	4 34	4 14	3 59	3 46	3 26	3 12	3 2	2 55	2 49	2 45	2 42	2 40	2 38	37
38	6 17	5 36	5 5	4 39	4 19	4 3	3 50	3 29	3 15	3 4	2 57	2 51	2 46	2 43	2 41	2 39	38
39	6 24	5 42	5 10	4 44	4 24	4 7	3 54	3 32	3 17	3 6	2 58	2 52	2 47	2 44	2 42	2 40	39
40	6 31	5 48	5 15	4 49	4 28	4 11	3 57	3 35	3 20	3 8	3 0	2 54	2 49	2 45	2 43	2 40	40
41	6 38	5 54	5 20	4 54	4 33	4 15	4 1	3 38	3 22	3 10	3 1	2 55	2 50	2 46	2 43	2 41	41
42	6 45	5 59	5 25	4 58	4 37	4 18	4 5	3 41	3 24	3 12	3 3	2 56	2 51	2 47	2 44	2 41	42
43	6 52	6 5	5 30	5 3	4 41	4 22	4 9	3 44	3 27	3 14	3 5	2 58	2 52	2 48	2 45	2 42	43
44	6 59	6 11	5 36	5 7	4 45	4 26	4 12	3 47	3 29	3 16	3 6	2 59	2 53	2 49	2 46	2 43	44
45	7 6	6 17	5 41	5 12	4 49	4 30	4 16	3 50	3 31	3 18	3 8	3 1	2 55	2 50	2 47		45
46	7 12	6 22	5 46	5 16	4 53	4 34	4 19	3 52	3 33	3 20	3 10	3 2	2 56	2 51	2 47		46
47	7 18	6 27	5 51	5 20	4 57	4 37	4 22	3 55	3 36	3 22	3 12	3 4	2 58	2 52			47
48	7 24	6 32	5 56	5 24	5 0	4 41	4 25	3 57	3 38	3 24	3 13	3 5	2 59	2 53			48
49	7 30	6 37	6 1	5 28	5 4	4 44	4 28	4 0	3 41	3 26	3 15	3 7	3 0				49
50	7 36	6 42	6 5	5 32	5 7	4 47	4 31	4 2	3 43	3 28	3 17	3 8	3 1				50
51	7 42	6 47	6 10	5 36	5 11	4 50	4 34	4 5	3 45	3 30	3 18	3 9					51
52	7 47	6 52	6 14	5 40	5 14	4 53	4 37	4 7	3 47	3 32	3 19	3 10					52
53	7 53	6 57	6 18	5 43	5 18	4 56	4 39	4 10	3 49	3 34	3 20						53
54	7 58	7 2	6 22	5 47	5 21	4 59	4 42	4 12	3 51	3 35	3 21						54
55	8 4	7 7	6 26	5 51	5 24	5 2	4 45	4 14	3 53	3 36							55
56	8 9	7 11	6 30	5 54	5 27	5 5	4 47	4 16	3 55	3 38							56
57	8 14	7 16	6 34	5 58	5 30	5 8	4 50	4 18	3 57								57
58	8 19	7 20	6 38	6 1	5 33	5 11	4 52	4 20	3 58								58
59	8 24	7 25	6 42	6 4	5 36	5 14	4 54	4 22									59
60	8 28	7 29	6 45	6 8	5 39	5 16	4 56	4 24									60
61	8 33	7 33	6 48	6 11	5 42	5 19	4 58										61
62	8 37	7 37	6 51	6 14	5 45	5 21	5 0										62
63	8 41	7 40	6 54	6 17	5 48	5 23											63
64	8 45	7 43	6 57	6 20													64
66	8 53	7 46	7 0														66
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 108°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App Alt.
	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	52°	54°	56°	58°	62°	66°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	5 30	5 45	6 0	6 15	6 29	6 44	6 58	7 11	7 23	7 34	7 45	7 56	8 6	8 16	8 35	8 53	6
7	4 55	5 8	5 21	5 34	5 46	5 58	6 10	6 22	6 33	6 43	6 53	7 2	7 11	7 20	7 35	7 47	7
8	4 29	4 41	4 52	5 3	5 13	5 23	5 34	5 44	5 54	6 4	6 13	6 22	6 30	6 38	6 51	7 1	8
9	4 8	4 18	4 28	4 38	4 48	4 57	5 6	5 15	5 23	5 31	5 38	5 45	5 53	6 1	6 14		9
10	3 52	4 0	4 9	4 18	4 27	4 36	4 44	4 52	4 59	5 6	5 13	5 20	5 27	5 33	5 45		10
11	3 38	3 46	3 54	4 2	4 10	4 18	4 25	4 33	4 40	4 47	4 53	4 59	5 5	5 11	5 20		11
12	3 27	3 34	3 41	3 48	3 56	4 4	4 11	4 18	4 24	4 30	4 36	4 42	4 47	4 52	5 0		12
13	3 18	3 24	3 30	3 37	3 44	3 51	3 58	4 4	4 10	4 15	4 21	4 26	4 30	4 34			13
14	3 10	3 16	3 22	3 28	3 34	3 40	3 46	3 52	3 58	4 3	4 8	4 12	4 16	4 20			14
15	3 4	3 9	3 14	3 20	3 25	3 31	3 36	3 42	3 47	3 52	3 56	4 1	4 5	4 8			15
16	2 59	3 3	3 8	3 13	3 18	3 23	3 28	3 33	3 38	3 43	3 47	3 51	3 55	3 58			16
17	2 54	2 58	3 3	3 7	3 12	3 17	3 21	3 26	3 30	3 35	3 39	3 43	3 46				17
18	2 51	2 54	2 59	3 3	3 7	3 11	3 15	3 20	3 24	3 28	3 32	3 35	3 38				18
19	2 48	2 51	2 55	2 59	3 3	3 6	3 10	3 14	3 18	3 22	3 25	3 28					19
20	2 46	2 49	2 52	2 56	2 59	3 2	3 6	3 9	3 13	3 16	3 19	3 22					20
21	2 44	2 47	2 50	2 53	2 56	2 59	3 2	3 5	3 9	3 12	3 14						21
22	2 42	2 45	2 48	2 50	2 53	2 56	2 59	3 2	3 5	3 8	3 10						22
23	2 41	2 43	2 46	2 48	2 50	2 53	2 56	2 59	3 2	3 4							23
24	2 40	2 42	2 44	2 46	2 48	2 51	2 53	2 56	2 59	3 1							24
25	2 39	2 40	2 42	2 44	2 46	2 49	2 51	2 53	2 56								25
26	2 38	2 39	2 41	2 43	2 45	2 47	2 49	2 51	2 54								26
27	2 37	2 38	2 40	2 42	2 44	2 45	2 47	2 49									27
28	2 36	2 38	2 39	2 41	2 42	2 44	2 46	2 47									28
29	2 36	2 37	2 38	2 40	2 41	2 42	2 44										29
30	2 35	2 36	2 37	2 39	2 40	2 41	2 43										30
31	2 35	2 36	2 37	2 38	2 39	2 40											31
32	2 35	2 36	2 37	2 38	2 39	2 40											32
33	2 36	2 36	2 36	2 37	2 38												33
34	2 36	2 36	2 36	2 37	2 36												34
35	2 36	2 36	2 36	2 37													35
36	2 37	2 36	2 36	2 36													36
37	2 38	2 37	2 36														37
38	2 38	2 37	2 36														38
39	2 39	2 38															39
40	2 39	2 38															40
41	2 40																41
42	2 40																42
43																	43
44																	44
45																	45
46																	46
47																	47
48																	
49																	
50																	
51																	
52																	
53																	
54																	
55																	
56																	
57																	
58																	
59																	
60																	
61																	
62																	
63																	
64																	
66																	
	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	52°						

Table P. Effect of Sun's Par.

To be subtracted from the Third Correction.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	65	80	90
	″	″	″	″	″	″	″	″	″	″
5	1	1	2	2	3	3	3	3		
10	2	2	3	3	4	4	4			
15	3	3	3	4	4	5	5			
20	4	4	4	5	5	5				
25	4	4	5	6	6	6				
30	5	5	6	6	7					
35	6	6	6	7	7					
40	6	7	7	8						
45	7	7	8	8						
50	8	8	8							
55	8	8	9							
60	8	9								
65	9									
70										

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 112°.

☽'s App. Alt.	*Apparent Altitude of the Sun, Star or Planet.*																☽'s App. Alt.
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	°
6	2 40	2 42	2 45	2 49	2 54	3 0	3 7	3 21	3 36	3 52	4 8	4 24	4 40	4 56	5 12	5 28	6
7	2 42	2 40	2 42	2 45	2 49	2 53	2 58	3 8	3 20	3 33	3 46	3 59	4 13	4 26	4 40	4 54	7
8	2 46	2 42	2 41	2 43	2 45	2 48	2 52	3 0	3 9	3 19	3 31	3 42	3 54	4 6	4 18	4 30	8
9	2 51	2 45	2 43	2 41	2 43	2 45	2 48	2 54	3 1	3 9	3 19	3 29	3 40	3 50	4 0	4 11	9
10	2 57	2 49	2 45	2 43	2 42	2 43	2 45	2 49	2 55	3 2	3 10	3 19	3 28	3 37	3 46	3 56	10
11	3 3	2 54	2 48	2 45	2 43	2 42	2 43	2 46	2 50	2 56	3 3	3 11	3 19	3 27	3 35	3 44	11
12	3 9	2 59	2 52	2 48	2 45	2 43	2 42	2 44	2 47	2 52	2 58	3 5	3 12	3 19	3 26	3 34	12
13	3 16	3 4	2 56	2 51	2 47	2 45	2 43	2 43	2 45	2 49	2 54	3 0	3 6	3 12	3 18	3 25	13
14	3 23	3 10	3 0	2 54	2 50	2 47	2 45	2 43	2 44	2 47	2 51	2 56	3 1	3 6	3 12	3 17	14
15	3 31	3 16	3 5	2 58	2 53	2 49	2 47	2 44	2 44	2 46	2 49	2 53	2 57	3 1	3 6	3 11	15
16	3 39	3 22	3 10	3 2	2 56	2 51	2 48	2 45	2 43	2 45	2 47	2 50	2 54	2 57	3 2	3 6	16
17	3 47	3 29	3 15	3 6	2 59	2 54	2 50	2 46	2 44	2 44	2 46	2 48	2 51	2 54	2 58	3 2	17
18	3 55	3 35	3 20	3 10	3 2	2 57	2 53	2 48	2 45	2 44	2 45	2 47	2 49	2 52	2 55	2 59	18
19	4 3	3 41	3 26	3 15	3 6	3 0	2 56	2 50	2 46	2 45	2 44	2 46	2 48	2 50	2 53	2 56	19
20	4 11	3 48	3 32	3 20	3 10	3 3	2 58	2 52	2 48	2 45	2 44	2 45	2 47	2 49	2 51	2 54	20
21	4 19	3 54	3 38	3 25	3 15	3 7	3 1	2 54	2 49	2 46	2 44	2 44	2 46	2 48	2 50	2 52	21
22	4 27	4 1	3 44	3 30	3 20	3 11	3 5	2 56	2 51	2 47	2 45	2 44	2 45	2 47	2 49	2 51	22
23	4 35	4 8	3 50	3 35	3 24	3 15	3 8	2 58	2 52	2 48	2 46	2 45	2 44	2 46	2 48	2 50	23
24	4 43	4 15	3 56	3 40	3 28	3 19	3 11	3 1	2 54	2 49	2 47	2 45	2 44	2 45	2 47	2 49	24
25	4 52	4 22	4 3	3 46	3 33	3 23	3 15	3 3	2 55	2 51	2 48	2 46	2 45	2 44	2 46	2 48	25
26	5 0	4 29	4 9	3 51	3 38	3 27	3 18	3 5	2 57	2 52	2 49	2 47	2 45	2 44	2 45	2 47	26
27	5 8	4 37	4 15	3 56	3 42	3 31	3 22	3 8	2 59	2 54	2 51	2 48	2 45	2 45	2 45	2 46	27
28	5 16	4 44	4 21	4 2	3 47	3 36	3 26	3 11	3 2	2 56	2 52	2 49	2 46	2 46	2 45	2 46	28
29	5 24	4 51	4 27	4 7	3 52	3 40	3 31	3 14	3 5	2 58	2 53	2 50	2 46	2 46	2 45	2 46	29
30	5 32	4 57	4 33	4 12	3 57	3 45	3 35	3 17	3 7	3 0	2 55	2 52	2 47	2 47	2 46	2 46	30
31	5 40	5 4	4 39	4 17	4 2	3 49	3 39	3 20	3 9	3 2	2 57	2 53	2 49	2 48	2 47	2 46	31
32	5 48	5 10	4 45	4 22	4 7	3 51	3 43	3 23	3 12	3 4	2 58	2 54	2 51	2 49	2 47	2 46	32
33	5 56	5 17	4 51	4 28	4 12	3 58	3 46	3 26	3 14	3 6	3 0	2 55	2 52	2 50	2 48	2 47	33
34	6 4	5 24	4 56	4 33	4 16	4 2	3 50	3 29	3 17	3 8	3 2	2 57	2 53	2 51	2 49	2 48	34
35	6 11	5 31	5 2	4 38	4 21	4 6	3 53	3 32	3 19	3 10	3 4	2 59	2 55	2 52	2 50	2 49	35
36	6 19	5 37	5 7	4 43	4 25	4 10	3 57	3 35	3 21	3 12	3 5	3 0	2 56	2 53	2 51	2 49	36
37	6 26	5 44	5 13	4 48	4 29	4 14	4 1	3 38	3 24	3 14	3 7	3 1	2 57	2 54	2 52	2 50	37
38	6 33	5 50	5 18	4 53	4 33	4 17	4 4	3 41	3 26	3 16	3 9	3 3	2 58	2 55	2 53	2 51	38
39	6 41	5 56	5 24	4 58	4 37	4 21	4 8	3 44	3 29	3 18	3 10	3 4	2 59	2 56	2 54	2 52	39
40	6 48	6 2	5 29	5 3	4 41	4 25	4 11	3 47	3 32	3 20	3 12	3 6	3 1	2 57	2 55	2 53	40
41	6 55	6 8	5 35	5 8	4 45	4 28	4 15	3 50	3 35	3 22	3 13	3 7	3 2	2 58	2 55		41
42	7 2	6 14	5 40	5 13	4 49	4 32	4 18	3 53	3 38	3 25	3 15	3 8	3 3	2 59	2 56		42
43	7 8	6 20	5 46	5 18	4 53	4 36	4 22	3 56	3 40	3 27	3 17	3 10	3 5	3 0			43
44	7 15	6 26	5 51	5 23	4 58	4 40	4 25	3 59	3 42	3 29	3 19	3 12	3 6	3 1			44
45	7 22	6 32	5 56	5 28	5 3	4 44	4 28	4 2	3 45	3 31	3 21	3 14	3 8				45
46	7 28	6 38	6 2	5 33	5 8	4 47	4 31	4 5	3 47	3 33	3 23	3 15	3 9				46
47	7 35	6 44	6 7	5 37	5 12	4 51	4 34	4 8	3 50	3 36	3 25	3 16					47
48	7 42	6 49	6 12	5 41	5 16	4 55	4 38	4 11	3 52	3 38	3 26	3 17					48
49	7 48	6 54	6 16	5 45	5 20	4 58	4 41	4 14	3 55	3 40	3 28						49
50	7 55	6 59	6 21	5 49	5 23	5 2	4 44	4 17	3 57	3 42	3 29						50
51	8 1	7 4	6 25	5 53	5 27	5 5	4 47	4 19	3 59	3 44							51
52	8 7	7 9	6 29	5 57	5 30	5 8	4 50	4 22	4 1	3 46							52
53	8 13	7 14	6 34	6 1	5 34	5 12	4 53	4 24	4 3								53
54	8 19	7 19	6 38	6 5	5 37	5 15	4 56	4 26	4 4								54
55	8 25	7 23	6 42	6 8	5 41	5 18	4 59	4 28									55
56	8 30	7 28	6 47	6 12	5 44	5 21	5 1	4 30									56
57	8 35	7 33	6 51	6 15	5 47	5 24	5 4										57
58	8 40	7 38	6 55	6 19	5 50	5 27	5 6										58
59	8 45	7 43	6 59	6 22	5 53	5 29											59
60	8 50	7 48	7 2	6 25	5 56												60
61	8 54	7 52	7 5	6 28													61
62	8 58	7 56	7 8														62
63	9 2	7 59															63
64	9 5																64
65																	65
	6°	7°	8°	9°	10°	11°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 112°.

D's App. Alt.	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	52°	54°	56°	58°	60°	62°	D's App. Alt.
	Apparent Altitude of the Sun, Star or Planet.																
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	5 44	6 0	6 16	6 31	6 46	7 0	7 14	7 27	7 40	7 53	8 5	8 18	8 30	8 41	8 50	8 58	6
7	5 7	5 21	5 34	5 47	6 0	6 13	6 25	6 37	6 49	7 0	7 10	7 20	7 30	7 39	7 47	7 55	7
8	4 42	4 54	5 5	5 16	5 27	5 38	5 49	6 0	6 10	6 20	6 29	6 38	6 47	6 55	7 2	7 8	8
9	4 21	4 32	4 42	4 52	5 1	5 11	5 21	5 31	5 40	5 48	5 56	6 4	6 11	6 18	6 24		9
10	4 5	4 14	4 23	4 32	4 40	4 49	4 58	5 7	5 15	5 23	5 31	5 38	5 44	5 50	5 55		10
11	3 52	4 0	4 8	4 16	4 23	4 31	4 39	4 47	4 55	5 2	5 8	5 14	5 19	5 24			11
12	3 41	3 48	3 55	4 2	4 9	4 16	4 24	4 31	4 38	4 44	4 50	4 56	5 1	5 5			12
13	3 31	3 38	3 44	3 50	3 57	4 4	4 10	4 17	4 23	4 29	4 35	4 40	4 45				13
14	3 23	3 29	3 35	3 41	3 47	3 53	3 59	4 6	4 12	4 17	4 22	4 26	4 30				14
15	3 16	3 21	3 27	3 33	3 38	3 44	3 50	3 56	4 1	4 6	4 10	4 14					15
16	3 10	3 15	3 21	3 26	3 31	3 37	3 42	3 47	3 52	3 57	4 1	4 4					16
17	3 6	3 11	3 16	3 20	3 25	3 30	3 35	3 40	3 45	3 49	3 53						17
18	3 3	3 7	3 12	3 16	3 20	3 25	3 29	3 34	3 38	3 42	3 46						18
19	3 0	3 4	3 8	3 12	3 16	3 20	3 24	3 28	3 32	3 35							19
20	2 57	3 1	3 5	3 8	3 12	3 16	3 20	3 23	3 26	3 29							20
21	2 55	2 58	3 2	3 5	3 9	3 12	3 16	3 19	3 22								21
22	2 53	2 56	3 0	3 3	3 6	3 9	3 12	3 15	3 18								22
23	2 52	2 55	2 58	3 1	3 3	3 6	3 9	3 12									23
24	2 51	2 53	2 56	2 59	3 1	3 4	3 7	3 9									24
25	2 50	2 52	2 54	2 57	2 59	3 1	3 4										25
26	2 49	2 51	2 53	2 55	2 57	2 59	3 1										26
27	2 48	2 50	2 52	2 54	2 56	2 57											27
28	2 47	2 49	2 51	2 53	2 55	2 56											28
29	2 47	2 48	2 50	2 52	2 54												29
30	2 47	2 48	2 49	2 51	2 53												30
31	2 47	2 48	2 49	2 50													31
32	2 47	2 48	2 49	2 50													32
33	2 47	2 48	2 49														33
34	2 48	2 48	2 49														34
35	2 48	2 48															35
36	2 49	2 48															36
37	2 49																37
38	2 50																38
39																	39
40																	40
41																	41
42																	42
43																	43
44																	44
45																	45
46																	46
47																	47
48																	48
49																	49
50																	
51																	
52																	
53																	
54																	
55																	
56																	
57																	
58																	
59																	
60																	
61																	
62																	
63																	
64																	
65																	
	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	52°						

Table P. *Effect of Sun's Par.*

To be subtracted from the Third Correction.

D's App. Alt.	5	10	20	30	40	50	60	65	[illegible]	90
	Sun's Apparent Altitude.									
	″	″	″	″	″	″	″	″	″	″
5	1	2	2	3	3	4	4	4		
10	2	2	3	4	4	5	5			
15	3	3	4	4	5	5				
20	4	4	4	5	6	6				
25	4	5	5	6	6					
30	5	5	6	7	7					
35	6	6	7	7						
40	7	7	7	8						
45	7	7	8							
50	8	8	8							
55	8	9								
60	9	9								
65	9									

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 116°.

☽'s App. Alt.	*Apparent Altitude of the Sun, Star or Planet.*																☽'s App. Alt.
	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	18°	20°	22°	24°	26°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	2 50	2 52	2 55	2 59	3 4	3 10	3 17	3 25	3 33	3 41	3 49	4 5	4 22	4 39	4 56	5 13	6
7	2 52	2 50	2 52	2 55	2 58	3 2	3 8	3 13	3 19	3 25	3 32	3 46	4 0	4 14	4 28	4 42	7
8	2 56	2 52	2 50	2 52	2 54	2 57	3 1	3 5	3 10	3 15	3 21	3 32	3 44	3 56	4 8	4 20	8
9	3 1	2 55	2 52	2 50	2 52	2 54	2 57	3 0	3 4	3 8	3 13	3 21	3 31	3 42	3 53	4 4	9
10	3 7	2 59	2 55	2 52	2 51	2 52	2 54	2 57	3 0	3 3	3 7	3 14	3 22	3 31	3 41	3 50	10
11	3 13	3 4	2 58	2 54	2 52	2 51	2 53	2 55	2 57	3 0	3 3	3 9	3 16	3 23	3 31	3 39	11
12	3 20	3 9	3 2	2 57	2 54	2 53	2 52	2 53	2 55	2 57	3 0	3 5	3 10	3 16	3 23	3 30	12
13	3 27	3 15	3 6	3 1	2 57	2 55	2 53	2 52	2 53	2 55	2 58	3 2	3 6	3 11	3 17	3 23	13
14	3 35	3 21	3 11	3 5	3 0	2 57	2 55	2 53	2 52	2 54	2 56	2 59	3 3	3 7	3 12	3 18	14
15	3 43	3 27	3 16	3 9	3 4	3 0	2 57	2 55	2 53	2 53	2 54	2 57	3 0	3 4	3 8	3 14	15
16	3 51	3 33	3 21	3 13	3 7	3 3	3 0	2 57	2 55	2 54	2 53	2 55	2 58	3 1	3 5	3 10	16
17	3 59	3 40	3 27	3 17	3 11	3 6	3 2	2 59	2 57	2 55	2 54	2 55	2 57	2 59	3 3	3 7	17
18	4 7	3 47	3 33	3 22	3 14	3 9	3 5	3 1	2 59	2 56	2 55	2 54	2 56	2 58	3 1	3 5	18
19	4 16	3 54	3 39	3 27	3 18	3 12	3 8	3 4	3 1	2 58	2 56	2 55	2 55	2 57	3 0	3 3	19
20	4 24	4 1	3 45	3 32	3 22	3 16	3 11	3 7	3 3	3 0	2 58	2 56	2 55	2 57	2 59	3 2	20
21	4 33	4 8	3 51	3 37	3 27	3 20	3 14	3 9	3 5	3 2	3 0	2 57	2 56	2 57	2 59	3 1	21
22	4 41	4 15	3 57	3 43	3 32	3 24	3 17	3 12	3 7	3 4	3 2	2 59	2 57	2 56	2 58	3 0	22
23	4 49	4 22	4 4	3 49	3 37	3 28	3 21	3 15	3 10	3 7	3 4	3 0	2 58	2 57	2 58	3 0	23
24	4 58	4 29	4 10	3 54	3 42	3 32	3 24	3 18	3 13	3 10	3 7	3 2	2 59	2 58	2 57	2 59	24
25	5 6	4 36	4 16	4 0	3 47	3 37	3 28	3 21	3 16	3 12	3 9	3 4	3 1	2 59	2 58	2 59	25
26	5 15	4 43	4 22	4 5	3 52	3 41	3 32	3 24	3 18	3 14	3 11	3 6	3 2	3 0	2 59	2 58	26
27	5 23	4 50	4 28	4 11	3 57	3 45	3 35	3 27	3 21	3 16	3 13	3 8	3 4	3 2	3 0	2 59	27
28	5 31	4 57	4 34	4 16	4 1	3 49	3 39	3 31	3 24	3 19	3 15	3 9	3 5	3 3	3 1	2 59	28
29	5 39	5 4	4 40	4 21	4 6	3 54	3 43	3 34	3 27	3 21	3 17	3 11	3 7	3 4	3 2	3 0	29
30	5 47	5 11	4 46	4 26	4 10	3 58	3 47	3 38	3 30	3 24	3 19	3 13	3 8	3 5	3 3	3 1	30
31	5 55	5 18	4 52	4 32	4 15	4 2	3 51	3 42	3 34	3 27	3 22	3 15	3 10	3 6	3 4	3 2	31
32	6 3	5 26	4 58	4 37	4 20	4 6	3 55	3 45	3 37	3 30	3 25	3 17	3 12	3 8	3 5	3 3	32
33	6 12	5 33	5 5	4 42	4 25	4 11	3 59	3 48	3 40	3 33	3 27	3 19	3 13	3 9	3 6	3 4	33
34	6 20	5 40	5 11	4 47	4 30	4 15	4 2	3 52	3 43	3 36	3 30	3 21	3 15	3 10	3 7	3 5	34
35	6 29	5 47	5 17	4 53	4 35	4 20	4 6	3 55	3 47	3 40	3 33	3 24	3 17	3 12	3 9	3 6	35
36	6 37	5 55	5 23	4 58	4 40	4 24	4 10	3 59	3 50	3 43	3 36	3 26	3 19	3 14	3 10	3 7	36
37	6 45	6 2	5 29	5 4	4 45	4 29	4 14	4 2	3 53	3 46	3 39	3 29	3 21	3 15	3 11	3 8	37
38	6 53	6 9	5 35	5 9	4 50	4 33	4 18	4 6	3 57	3 49	3 42	3 31	3 23	3 17	3 13	3 9	38
39	7 1	6 16	5 41	5 15	4 54	4 37	4 22	4 10	4 0	3 52	3 45	3 33	3 25	3 19	3 15		39
40	7 8	6 23	5 47	5 20	4 58	4 41	4 26	4 13	4 3	3 54	3 47	3 36	3 27	3 20	3 16		40
41	7 15	6 29	5 53	5 25	5 3	4 45	4 30	4 17	4 6	3 57	3 50	3 39	3 29	3 21			41
42	7 22	6 35	5 58	5 30	5 7	4 49	4 33	4 20	4 9	4 0	3 53	3 41	3 31	3 23			42
43	7 30	6 41	6 4	5 35	5 12	4 53	4 37	4 23	4 12	4 3	3 55	3 43	3 33				43
44	7 37	6 47	6 9	5 40	5 16	4 57	4 41	4 27	4 15	4 6	3 58	3 45	3 34				44
45	7 45	6 53	6 15	5 45	5 21	5 1	4 44	4 30	4 18	4 9	4 1	3 47					45
46	7 52	6 59	6 20	5 49	5 25	5 5	4 48	4 33	4 21	4 11	4 3	3 49					46
47	7 59	7 5	6 25	5 54	5 29	5 9	4 52	4 37	4 24	4 14	4 6						47
48	8 6	7 10	6 30	5 59	5 33	5 13	4 55	4 40	4 27	4 17	4 8						48
49	8 12	7 15	6 35	6 4	5 37	5 16	4 58	4 43	4 30	4 19							49
50	8 18	7 20	6 40	6 8	5 41	5 20	5 1	4 46	4 33								50
51	8 24	7 26	6 45	6 12	5 45	5 23	5 4	4 49									51
52	8 30	7 31	6 50	6 16	5 49	5 27	5 7										52
53	8 36	7 37	6 55	6 20	5 53	5 30											53
54	8 42	7 42	6 59	6 24	5 56												54
55	8 48	7 47	7 3	6 28													55
56	8 54	7 52	7 7														56
57	8 59	7 57															57
58	9 3																58
59																	59
60																	60
61																	61
62																	62
63																	63
64																	64
65																	65
	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	18°	20°	22°	24°	26°	

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 116°.

☽'s App. Alt.	Apparent Altitude of the Sun, Star or Planet.																☽'s App. Alt.
	28°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	52°	54°	56°	58°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	5 30	5 46	6 3	6 19	6 36	6 52	7 7	7 22	7 36	7 51	8 5	8 18	8 30	8 42	8 53	9 3	6
7	4 56	5 10	5 25	5 40	5 55	6 9	6 22	6 34	6 46	6 58	7 9	7 20	7 31	7 42	7 52		7
8	4 33	4 45	4 58	5 11	5 24	5 36	5 47	5 58	6 8	6 18	6 28	6 38	6 48	6 58	7 8		8
9	4 15	4 26	4 37	4 47	4 58	5 8	[illegible] 19	5 29	5 39	5 49	5 59	6 8	6 16	6 24			9
10	4 0	4 10	4 20	4 29	4 39	4 48	4 58	5 7	5 16	5 25	5 33	5 41	5 49	5 56			10
11	3 48	3 57	4 6	4 15	4 23	4 32	4 41	4 49	4 57	5 5	5 12	5 19	5 25				11
12	3 38	3 46	3 54	4 2	4 10	4 18	4 26	4 34	4 41	4 48	4 54	5 1	5 7				12
13	3 30	3 37	3 44	3 52	4 0	4 7	4 14	4 21	4 27	4 33	4 39	4 45					13
14	3 24	3 30	3 37	3 44	3 51	3 57	4 4	4 10	4 16	4 21	4 27	4 33					14
15	3 19	3 25	3 31	3 37	3 43	3 49	3 55	4 1	4 6	4 11	4 17						15
16	3 15	3 20	3 26	3 31	3 37	3 42	3 47	3 53	3 58	4 2	4 8						16
17	3 12	3 16	3 21	3 26	3 31	3 36	3 41	3 46	3 51	3 55							17
18	3 9	3 13	3 17	3 22	3 26	3 31	3 36	3 40	3 45	3 49							18
19	3 7	3 10	3 14	3 18	3 22	3 27	3 31	3 35	3 39								19
20	3 5	3 8	3 11	3 15	3 19	3 23	3 27	3 31	3 34								20
21	3 4	3 6	3 9	3 12	3 16	3 20	3 23	3 27									21
22	3 3	3 5	3 7	3 10	3 14	3 17	3 20	3 23									22
23	3 2	3 4	3 6	3 9	3 12	3 15	3 18										23
24	3 1	3 3	3 5	3 8	3 10	3 13	3 16										24
25	3 0	3 2	3 4	3 7	3 9	3 11											25
26	3 0	3 2	3 4	3 6	3 7	3 9											26
27	3 0	3 1	3 3	3 5	3 6												27
28	2 59	3 0	3 2	3 4	3 5												28
29	2 59	3 0	3 1	3 3													29
30	3 0	3 0	3 1	3 3													30
31	3 1	3 0	3 1														31
32	3 2	3 1	3 2														32
33	3 2	3 1															33
34	3 3	3 2															34
35	3 4																35
36	3 5																36
37																	37
38																	38
39																	39
40																	40
41																	41
42																	42
43																	43
44																	44
45																	45
46																	46
47																	47
48																	48
49																	49
50																	
51																	
52																	
53																	
54																	
55																	
56																	
57																	
58																	
59																	
60																	
61																	
62																	
63																	
64																	
65																	
	28°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°						

Table P. Effect of Sun's Par.

To be subtracted from the Third Correction.

☽'s App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	60	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	2	2	2	3	4	4	5			
10	2	2	3	4	5	5				
15	3	3	4	5	5	6				
20	4	4	5	6	6					
25	5	5	6	6	7					
30	5	6	6	7						
35	6	6	7	8						
40	7	7	8							
45	7	8	8							
50	8	8								
55	9	9								
60	9									

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 120°.

D's App. Alt.	Apparent Altitude of the Sun, Star or Planet.																	D's App. Alt.
	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	22°	
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	°
6	3 1	3 3	3 6	3 11	3 17	3 24	3 32	3 39	3 47	3 55	4 4	4 12	4 21	4 30	4 39	4 57	6
7	3 3	3 2	3 4	3 7	3 11	3 16	3 22	3 28	3 34	3 40	3 47	3 54	4 1	4 8	4 15	4 30	7
8	3 7	3 4	3 3	3 5	3 8	3 11	3 15	3 20	3 25	3 29	3 35	3 40	3 46	3 52	3 59	4 12	8
9	3 12	3 8	3 5	3 4	3 6	3 8	3 11	3 14	3 18	3 22	3 26	3 31	3 36	3 41	3 47	3 58	9
10	3 18	3 12	3 8	3 6	3 5	3 6	3 8	3 10	3 14	3 17	3 20	3 24	3 28	3 33	3 38	3 47	10
11	3 25	3 17	3 12	3 8	3 6	3 5	3 6	3 8	3 11	3 13	3 16	3 19	3 22	3 26	3 30	3 38	11
12	3 33	3 23	3 16	3 11	3 8	3 6	3 5	3 7	3 9	3 11	3 13	3 15	3 18	3 21	3 24	3 31	12
13	3 41	3 28	3 20	3 15	3 11	3 8	3 6	3 6	3 8	3 9	3 11	3 13	3 15	3 17	3 20	3 26	13
14	3 49	3 34	3 25	3 19	3 14	3 11	3 8	3 7	3 7	3 8	3 9	3 11	3 12	3 14	3 17	3 22	14
15	3 57	3 41	3 30	3 23	3 18	3 14	3 11	3 9	3 8	3 7	3 8	3 9	3 11	3 12	3 14	3 18	15
16	4 6	3 48	3 36	3 28	3 22	3 17	3 13	3 11	3 9	3 8	3 8	3 9	3 10	3 11	3 12	3 16	16
17	4 14	3 55	3 42	3 32	3 25	3 20	3 15	3 12	3 10	3 9	3 9	3 9	3 9	3 10	3 11	3 14	17
18	4 23	4 3	3 48	3 37	3 29	3 23	3 18	3 14	3 12	3 11	3 10	3 9	3 9	3 10	3 11	3 13	18
19	4 32	4 10	3 54	3 42	3 33	3 26	3 21	3 17	3 15	3 13	3 11	3 10	3 10	3 9	3 10	3 12	19
20	4 40	4 17	4 1	3 48	3 38	3 30	3 24	3 20	3 17	3 15	3 13	3 12	3 11	3 10	3 10	3 12	20
21	4 49	4 24	4 7	3 53	3 42	3 34	3 28	3 23	3 19	3 17	3 15	3 13	3 12	3 11	3 10	3 11	21
22	4 58	4 31	4 14	3 58	3 47	3 39	3 32	3 26	3 22	3 19	3 16	3 14	3 13	3 12	3 11	3 11	22
23	5 7	4 39	4 21	4 4	3 52	3 43	3 36	3 30	3 25	3 21	3 18	3 16	3 14	3 13	3 12	3 12	23
24	5 16	4 46	4 27	4 10	3 57	3 47	3 39	3 33	3 28	3 23	3 20	3 18	3 16	3 15	3 14	3 13	24
25	5 25	4 53	4 33	4 15	4 2	3 51	3 43	3 36	3 31	3 26	3 23	3 20	3 18	3 17	3 15	3 14	25
26	5 34	5 1	4 40	4 20	4 7	3 56	3 47	3 39	3 34	3 29	3 25	3 22	3 20	3 18	3 16	3 15	26
27	5 42	5 8	4 47	4 25	4 12	4 1	3 51	3 43	3 37	3 32	3 28	3 25	3 22	3 20	3 18	3 16	27
28	5 51	5 16	4 53	4 31	4 17	4 5	3 55	3 47	3 40	3 35	3 30	3 27	3 24	3 22	3 20	3 17	28
29	6 0	5 24	5 0	4 37	4 22	4 10	3 59	3 50	3 43	3 37	3 33	3 29	3 26	3 23	3 21	3 18	29
30	6 8	5 31	5 6	4 43	4 27	4 15	4 3	3 54	3 46	3 40	3 36	3 32	3 28	3 25	3 23	3 19	30
31	6 17	5 39	5 12	4 48	4 32	4 19	4 7	3 57	3 49	3 43	3 38	3 34	3 30	3 27	3 25	3 20	31
32	6 25	5 46	5 18	4 54	4 37	4 23	4 11	4 1	3 52	3 46	3 41	3 36	3 32	3 29	3 27	3 22	32
33	6 34	5 54	5 25	5 0	4 42	4 27	4 15	4 5	3 56	3 49	3 44	3 39	3 35	3 32	3 29	3 24	33
34	0 43	6 2	5 31	5 6	4 47	4 32	4 19	4 9	3 59	3 52	3 47	3 42	3 37	3 34	3 31	3 26	34
35	6 51	6 9	5 38	5 12	4 52	4 37	4 24	4 12	4 2	3 55	3 50	3 45	3 40	3 36	3 33	3 28	35
36	6 59	6 16	5 44	5 18	4 57	4 42	4 28	4 15	4 5	3 58	3 53	3 47	3 42	3 38	3 35	3 30	36
37	7 8	6 23	5 50	5 23	5 2	4 46	4 32	4 19	4 9	4 2	3 56	3 50	3 45	3 41	3 37	3 31	37
38	7 16	6 30	5 56	5 28	5 7	4 50	4 36	4 23	4 13	4 5	3 59	3 53	3 47	3 43	3 39	3 33	38
39	7 24	6 37	6 2	5 34	5 12	4 55	4 40	4 27	4 16	4 8	4 [illegible]	3 55	3 50	3 45	3 41		39
40	7 32	6 44	6 8	5 39	5 17	4 59	4 44	4 31	4 20	4 11	4 4	3 58	3 52	3 47	3 43		40
41	7 40	6 50	6 14	5 44	5 22	5 4	4 48	4 35	4 24	4 15	4 7	4 1	3 55	3 49			41
42	7 47	6 56	6 19	5 50	5 27	5 8	4 52	4 39	4 28	4 18	4 10	4 3	3 57				42
43	7 55	7 2	6 25	5 55	5 32	5 13	4 56	4 42	4 31	4 21	4 13	4 6					43
44	8 3	7 9	6 31	6 0	5 37	5 17	5 0	4 46	4 34	4 24	4 16						44
45	8 11	7 15	6 36	6 5	5 42	5 22	5 4	4 49	4 37	4 27							45
46	8 18	7 21	6 41	6 10	5 46	5 26	5 8	4 53	4 40								46
47	8 25	7 27	6 46	6 15	5 51	5 30	5 11	4 56									47
48	8 32	7 33	6 52	6 20	5 55	5 34	5 14										48
49	8 39	7 39	6 57	6 25	5 59	5 37											49
50	8 45	7 45	7 2	6 30	6 3												50
51	8 51	7 51	7 8	6 34													
52	8 57	7 57	7 13														
53	9 3	8 3															
54	9 9																
55																	
56																	
57																	
58																	
59																	
60																	
61																	
62																	
63																	
64																	
65																	
	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°						

Table P. Effect of Sun's Par.

To be subtracted from the Third Correction.

D's App. Alt.	Sun's Apparent Altitude.									
	5	10	20	30	40	50	55	70	80	90
	″	″	″	″	″	″	″	″	″	″
5	2	2	3	3	4	5	5			
10	2	3	3	4	5	6				
15	3	4	4	5	6	7				
20	4	4	5	6	7					
25	5	5	6	7	7					
30	6	6	7	8						
35	6	7	8							
40	7	8	8							
45	8	8								
50	8	9								
55	9									

Digitized by Google

TABLE XLVIII.

Third Correction. Apparent Distance 120°.

D's App. Alt.	*Apparent Altitude of the Sun, Star or Planet.* 24°	26°	28°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	52°	54°	D's App. Alt.
°	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	°
6	5 15	5 32	5 49	6 6	6 23	6 41	6 58	7 14	7 30	7 46	8 2	8 17	8 31	8 44	8 57	9 9	6
7	4 45	5 0	5 15	5 30	5 45	6 0	6 15	6 29	6 43	6 56	7 8	7 21	7 33	7 45	7 57		7
8	4 25	4 38	4 51	5 4	5 17	5 30	5 43	5 56	6 8	6 20	6 31	6 42	6 53	7 3	7 13		8
9	4 9	4 20	4 31	4 43	4 55	5 7	5 18	5 28	5 38	5 49	6 0	6 10	6 20	6 29			9
10	3 57	4 7	4 17	4 27	4 37	4 47	4 57	5 7	5 17	5 27	5 37	5 46	5 55	6 3			10
11	3 47	3 56	4 5	4 14	4 23	4 32	4 42	4 51	4 59	5 8	5 17	5 25	5 33				11
12	3 39	3 47	3 55	4 3	4 11	4 19	4 28	4 36	4 44	4 52	5 0	5 7	5 14				12
13	3 32	3 39	3 46	3 53	4 0	4 8	4 16	4 24	4 31	4 38	4 46	4 53					13
14	3 27	3 33	3 39	3 46	3 52	3 59	4 6	4 13	4 20	4 27	4 34	4 40					14
15	3 23	3 29	3 34	3 40	3 46	3 52	3 58	4 4	4 11	4 18	4 24						15
16	3 20	3 25	3 30	3 36	3 41	3 46	3 52	3 58	4 4	4 10	4 16						16
17	3 18	3 22	3 27	3 32	3 36	3 41	3 47	3 52	3 58	4 3							17
18	3 16	3 20	3 24	3 28	3 32	3 37	3 42	3 47	3 52	3 57							18
19	3 15	3 18	3 21	3 25	3 29	3 33	3 38	3 43	3 47								19
20	3 14	3 16	3 19	3 23	3 27	3 31	3 35	3 39	3 43								20
21	3 13	3 15	3 17	3 21	3 24	3 28	3 32	3 36									21
22	3 12	3 14	3 16	3 19	3 22	3 26	3 29	3 33									22
23	3 12	3 13	3 15	3 18	3 21	3 24	3 27										23
24	3 12	3 13	3 15	3 17	3 20	3 23	3 26										24
25	3 12	3 13	3 15	3 17	3 19	3 21											25
26	3 13	3 14	3 15	3 16	3 18	3 20											26
27	3 14	3 14	3 15	3 16	3 18												27
28	3 15	3 14	3 15	3 16	3 18												28
29	3 16	3 15	3 15	3 16													29
30	3 17	3 16	3 16	3 16													30
31	3 18	3 17	3 17														31
32	3 19	3 18	3 18														32
33	3 21	3 19															33
34	3 22	3 20															34
35	3 24																35
36	3 26																36
37																	37
38																	38
39																	39
40																	40
41																	41
42																	42
43																	43
44																	44
45																	45
46																	46
47																	47
48																	48
49																	49
50																	50
51																	51
52																	52
53																	53
54																	54
55																	55
56																	56
57																	57
58																	58
59																	59
60																	60
61																	61
62																	62
63																	63
64																	64
65																	65
	24°	26°	28°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	52°	54°	

Digitized by Google

TABLE XLIX.

To find the correction of the apparent distance of the moon from any planet, on account of the parallax of the planet, supposing its horizontal parallax to be 35″. This is to be reduced to the actual horizontal parallax by means of Table L.

* Alt.	☽ Alt.	Apparent Distance. 20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
10°	10°	+1	-1	-2	-2	-3	-4	-5	-6	-7	-9	-10
	15	-8	-7	-6	-6	-7	-7	-8	-9	-10	-12	-14
	20	-17	-13	-11	-10	-10	-10	-11	-12	-13	-15	-17
	25	-20	-18	-15	-14	-13	-13	-14	-15	-16	-18	-20
	30	-24	-21	-20	-17	-16	-16	-17	-17	-19	-21	-23
	35	....	-29	-24	-21	-19	-19	-19	-20	-21	-24	-26
	40	....	-34	-28	-24	-22	-22	-22	-23	-24	-26	-29
	45	....	....	-31	-27	-25	-24	-24	-25	-26	-29	-32
	50	....	....	-34	-30	-27	-25	-26	-27	-28	-31	-34
	55	....	....	....	-32	-30	-28	-28	-29	-30	-33	
	60	....	....	....	-34	-31	-30	-30	-30	-32	-34	
	65	....	....	....	....	-33	-32	-31	-32	-33		
	70	....	....	....	....	-34	-33	-32	-33	-34		
	75	....	....	....	....	....	-34	-33	-34			
	80	....	....	....	....	....	-34	-34	-34			
	85	....	....	....	....	....	....	-34				
	90	....	....	....	....	....	....	-34				
15	10	+9	+5	+2	0	-2	-3	-4	-5	-6	-10	-12
	15	0	-1	-3	-4	-5	-6	-7	-9	-11	-13	-15
	20	-9	-7	-7	-8	-8	-9	-10	-12	-14	-16	-19
	25	-17	-13	-12	-11	-12	-12	-13	-15	-16	-19	-22
	30	-26	-19	-16	-15	-15	-15	-16	-17	-19	-22	-25
	35	-34	-24	-20	-18	-18	-18	-19	-20	-22	-25	-28
	40	....	-29	-24	-22	-20	-20	-21	-22	-24	-27	-31
	45	....	-34	-28	-25	-23	-23	-23	-25	-26	-30	-34
	50	....	....	-31	-27	-26	-25	-26	-27	-29	-32	
	55	....	....	-34	-30	-28	-27	-27	-29	-30	-34	
	60	....	....	....	-32	-30	-29	-29	-30	-32		
	65	....	....	....	-34	-31	-30	-31	-32	-34		
	70	....	....	....	....	-33	-32	-32	-33			
	75	....	....	....	....	-34	-33	-33	-34			
	80	....	....	....	....	....	-33	-33				
	85	....	....	....	....	....	-34	-34				
	90											
20	10	+16	+9	+5	+3	0	-2	-4	-6	-8	-11	-14
	15	+8	+4	+1	-1	-3	-5	-7	-9	-11	-14	-17
	20	-1	-2	-4	-5	-7	-8	-10	-12	-14	-17	-21
	25	-9	-8	-8	-9	-10	-11	-13	-15	-17	-20	-24
	30	-17	-14	-12	-13	-13	-14	-16	-17	-20	-23	-27
	35	-25	-19	-16	-16	-16	-17	-18	-20	-22	-25	-30
	40	-33	-24	-20	-19	-19	-19	-21	-23	-25	-28	-33
	45	....	-29	-24	-22	-21	-22	-23	-25	-27	-31	
	50	....	-33	-27	-25	-24	-24	-25	-27	-29	-33	
	55	....	....	-30	-27	-26	-26	-27	-29	-31		
	60	....	....	-33	-29	-28	-28	-29	-30	-33		
	65	....	....	....	-31	-30	-29	-30	-32			
	70	....	....	....	-33	-31	-31	-31	-33			
	75	....	....	....	....	-32	-32	-32				
	80	....	....	....	....	-33	-32	-33				
	85	....	....	....	....	....	-33					
	90	....	....	....	....	....	-33					
		20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°

* Alt.	☽ Alt.	Apparent Distance. 20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
25°	10°	+24	+14	+9	+5	+2	-1	-3	-6	-9	-12	-15
	15	+15	+8	+4	+1	-2	-4	-6	-9	-12	-15	-19
	20	+7	+3	-1	-3	-5	-7	-9	-12	-15	-18	-22
	25	-1	-3	-5	-7	-8	-10	-12	-15	-17	-21	[illegible]
	30	-9	-9	-9	-10	-11	-13	-15	-17	-20	-24	29
	35	-17	-14	-13	-14	-14	-16	-18	-20	-23	-27	32
	40	-25	-19	-17	-17	-17	-18	-20	-22	-25	-29	
	45	-32	-23	-21	-20	-20	-21	-22	-25	-28	-32	
	50	....	-28	-24	-22	-22	-23	-24	-27	-30		
	55	....	-32	-27	-25	-24	-25	-26	-29	-32		
	60	....	....	-29	-27	-26	-27	-28	-30			
	65	....	....	-32	-29	-28	-28	-30	-32			
	70	....	....	....	-31	-29	-30	-31				
	75	....	....	....	-32	-30	-31	-32				
	80	....	....	....	....	-31	-31					
	85	....	....	....	....	-32	-32					
	90											
30	10	+30	+19	+12	+7	+3	0	-3	-6	-9	-13	-17
	15	+22	+13	+7	+3	0	-3	-6	-9	-12	-16	-20
	20	+14	+7	+3	-1	-4	-6	-9	-12	-15	-19	-24
	25	+6	+2	-2	-4	-7	-9	-12	-15	-18	-22	-27
	30	-2	-4	-6	-8	-10	-12	-14	-17	-21	-25	-30
	35	-10	-9	-10	-11	-13	-15	-17	-20	-23	-28	
	40	-17	-14	-14	-14	-16	-17	-20	-23	-26	-30	
	45	-24	-19	-17	-17	-18	-20	-22	-25	-28		
	50	-30	-23	-21	-20	-21	-22	-24	-27	-30		
	55	....	-27	-24	-23	-23	-24	-26	-29			
	60	....	-30	-26	-25	-25	-26	-28	-30			
	65	....	....	-28	-27	-27	-27	-29				
	70	....	....	-30	-28	-28	-29	-30				
	75	....	....	....	-29	-29	-30					
	80	....	....	....	-30	-30	-30					
	85	....	....	....	....	-30						
	90	....	....	....	....	-30						
35	10	....	+23	+15	+9	+5	+1	-3	-6	-10	-14	-19
	15	+29	+17	+10	+5	+1	-2	-5	-9	-13	-17	-22
	20	+21	+12	+6	+2	-2	-5	-8	-12	-16	-20	-25
	25	+13	+6	+2	-2	-5	-8	-11	-15	-18	-23	-29
	30	+5	+1	-3	-6	-8	-11	-14	-17	-21	-26	
	35	-3	-5	-7	-9	-11	-14	-17	-20	-24	-29	
	40	-10	-10	-11	-12	-14	-16	-19	-22	-26		
	45	-16	-14	-14	-15	-17	-19	-22	-25	-29		
	50	-23	-18	-17	-18	-19	-21	-24	-27			
	55	-29	-22	-20	-20	-21	-23	-26	-29			
	60	....	-26	-23	-22	-23	-25	-27				
	65	....	-29	-25	-24	-25	-26	-29				
	70	....	....	-27	-26	-27	-28					
	75	....	....	-29	-27	-28	-29					
	80	....	....	....	-28	-28						
	85	....	....	....	-29	-29						
	90											
		20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°

Digitized by Google

TABLE XLIX

To find the correction of the apparent distance of the moon from any planet, on account of the parallax of the planet, supposing its horizontal parallax to be 35″. This is to be reduced to the actual horizontal parallax by means of Table L.

Apparent Distance.

✱ Alt.	☽ Alt.	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°
40°	10°	...	+27	+18	+11	+ 6	+ 2	− 2	− 6	−10	−15	−20
	15	...	+21	+13	+ 7	+ 3	− 1	− 5	− 9	−13	−18	−23
	20	+27	+16	+ 9	+ 3	− 1	− 4	− 8	−12	−16	−21	−27
	25	+19	+10	+ 4	0	− 4	− 7	−11	−15	−19	−24	
	30	+11	+ 5	0	− 4	− 7	−10	−14	−17	−22	−27	
	35	+ 4	− 1	− 4	− 7	−10	−13	−16	−20	−24		
	40	− 3	− 5	− 8	−10	−13	−16	−19	−23	−27		
	45	−10	−10	−11	−13	−16	−18	−21	−25			
	50	−16	−14	−15	−16	−18	−20	−22	−27			
	55	−22	−18	−18	−18	−20	−22	−25				
	60	−27	−21	−20	−21	−22	−24	−27				
	65	...	−24	−22	−22	−24	−26					
	70	....	−27	−24	−24	−25	−27					
	75	...	....	−26	−25	−26						
	80	....	....	−27	−26	−27						
	85	...	....	....	−27							
	90	...	....	....	−27							
45	10	....	..	+20	+13	+ 7	+ 3	− 2	− 6	−10	−15	−21
	15	...	+25	+15	+ 9	+ 4	0	− 5	− 9	−14	−19	−25
	20	..	+19	+11	+ 5	+ 1	− 4	− 8	−12	−17	−22	
	25	+25	+14	+ 7	+ 2	− 3	− 7	−11	−15	−19	−23	
	30	+17	+ 8	+ 3	− 2	− 6	− 9	−13	−17	−22		
	35	+10	+ 3	− 1	− 5	− 9	−12	−16	−20	−25		
	40	+ 3	− 2	− 5	− 8	−11	−15	−19	−23			
	45	− 4	− 6	− 9	−11	−14	−17	−21	−25			
	50	−10	−10	−12	−14	−17	−19	−23				
	55	−15	−14	−15	−17	−19	−21	−25				
	60	−20	−17	−18	−19	−21	−23					
	65	−25	−20	−20	−21	−23	−25					
	70	...	−23	−22	−22	−24						
	75	...	−25	−23	−23	−25						
	80	...	....	−24	−24							
	85	....	....	−25	−24							
	90											
50	10	...	....	+23	+15	+ 9	+ 3	− 2	− 6	−11	−16	−23
	15	...	....	+18	+11	+ 5	0	− 5	− 9	−14	−19	
	20	....	+23	+14	+ 7	+ 2	− 3	− 8	−12	−17	−23	
	25	...	+17	+ 9	+ 3	− 2	− 6	−10	−15	−20		
	30	+22	+12	+ 5	0	− 5	− 9	−13	−17	−23		
	35	+15	+ 7	+ 1	− 4	− 8	−11	−16	−20			
	40	+ 9	+ 2	− 3	− 7	−10	−14	−18	−23			
	45	+ 2	− 3	− 6	−10	−13	−16	−21				
	50	− 4	− 7	−10	−12	−15	−19	−23				
	55	− 9	−10	−12	−15	−18	−21					
	60	−14	−14	−15	−17	−19	−23					
	65	−19	−17	−17	−19	−21						
	70	−23	−19	−19	−20	−23						
	75	....	−21	−21	−22							
	80	....	−23	−22	−23							
	85	...	....	−22								
	90	...	....	−23								
		20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°

Apparent Distance.

✱ Alt.	☽ Alt.	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	115°
55°	10°	....	....	....	+16	+10	+ 4	− 1	− 6	−11	−17	−20
	15	....	....	+20	+12	+ 6	+ 1	− 4	− 9	−14	−20	
	20	....	....	+16	+ 8	+ 3	− 2	− 7	−12	−17		
	25	....	+20	+11	+ 5	− 1	− 5	−10	−15	−20		
	30	....	+15	+ 7	+ 1	− 4	− 8	−13	−17			
	35	+20	+10	+ 3	− 2	− 7	−11	−15	−20			
	40	+13	+ 5	− 1	− 5	− 9	−13	−18				
	45	+ 7	+ 1	− 4	− 8	−12	−16	−20				
	50	+ 1	− 4	− 8	−11	−14	−18					
	55	− 4	− 7	−11	−13	−17	−20					
	60	− 9	−11	−13	−15	−18						
	65	−14	−14	−15	−17	−20						
	70	−17	−16	−17	−19							
	75	−20	−18	−19	−20							
	80	....	−19	−19								
	85	....	−20	−20								
	90											
60	10	....	....	....	+17	+11	+ 5	− 1	− 6	−11	−17	
	15	...	....	....	+14	[illegible]	+ 2	− 4	− 9	−15		
	20	....	...	+17	+10	+ 4	− 2	− 7	−12	−17		
	25	...	....	+13	+ 6	0	− 5	−10	−15			
	30	....	+17	+ 9	+ 3	− 3	− 8	−13	−17			
	35	....	+13	+ 5	− 1	− 6	−10	−15				
	40	+17	+ 8	+ 1	− 4	− 8	−13	−17				
	45	+11	+ 3	− 2	− 7	−11	−15					
	50	+ 5	− 1	− 6	−10	−13	−17					
	55	0	− 5	− 9	−12	−16						
	60	− 5	− 8	−11	−14	−17						
	65	− 9	−11	−13	−16							
	70	−13	−13	−15	−17							
	75	−16	−15	−16								
	80	−17	−16	−17								
	85	....	−17									
	90	...	−17									
65	10	....	....	....	....	+11	+ 5	− 1	− 6	−12		
	15	....	....	....	+15	+ 8	+ 2	− 4	− 9	−15		
	20	[illegible]	....	....	+11	+ 5	− 1	− 7	−12			
	25	...	....	+15	+ 7	+ 1	− 4	−10	−15			
	30	....	....	+11	+ 4	− 2	− 7	−12				
	35	...	+15	+ 7	+ 1	− 5	−10	−15				
	40	....	+10	+ 3	− 3	− 8	−12					
	45	+15	+ 6	− 1	− 6	−10	−15					
	50	+ 9	+ 2	− 4	− 8	[illegible]						
	55	+ 4	− 2	− 7	−11	−15						
	60	− 1	− 5	− 9	−13							
	65	− 5	− 8	−12	−15							
	70	− 9	−11	−13								
	75	−12	−13	−15								
	80	−14	−14									
	85	−15	−15									
	90											
		20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	11[illegible]

Digitized by Google

TABLE XLIX.

To find the correction of the apparent distance of the moon from any planet, on account of the parallax of the planet, supposing its horizontal parallax to be 35″. This is to be reduced to the actual horizontal parallax by means of Table L.

✱ Alt.	☽ Alt.	20°	30°	40°	50°	60°	70°	80°	90°	100°
5°	°									
	10	....	....	....	....	+12	+ 6	− 1	− 6	−12
	15	....	....	....	....	+ 9	+ 2	− 4	− 9	
	20	....	....	....	+12	+ 5	− 1	− 7	−12	
	25	....	....	....	+ 8	+ 2	− 4	− 9		
	30	....	....	+12	+ 5	− 1	− 7	−12		
	35	....	....	+ 8	+ 2	− 4	− 9			
	40	....	+12	+ 4	− 2	− 7	−12			
	45	....	+ 8	+ 1	− 5	−10				
	50	+12	+ 3	− 2	− 7	−12				
	55	+ 7	0	− 5	− 9					
	60	+ 2	− 4	− 8	−12					
	70	− 6	− 9	−12						
	80	−10	−12							
75	10	....	....	....	....	....	+ 6	0	− 6	
	15	....	....	....	....	+ 9	+ 3	− 3	− 9	
	20	....	....	....	....	+ 6	0	− 6		
	25	....	....	....	+ 9	+ 2	− 3	− 9		
	30	....	....	....	+ 5	− 1	− 6			
	35	....	....	+ 9	+ 2	− 4	− 9			
	40	....	....	+ 5	− 1	− 6				
	45	....	+ 9	+ 2	− 4	− 9				
	50	....	+ 5	− 1	− 7					
	55	+ 9	+ 2	− 4	− 9					
	60	+ 4	− 2	− 7						
	80	− 8								

✱ Alt.	☽ Alt.	20°	30°	40°	50°	60°	70°	80°	90°	100°
°	°									
80	10	....	....	....	....	....	+ 6	0	− 6	
	15	....	....	....	....	....	+ 3	− 3		
	20	....	....	....	....	+ 6	0	− 6		
	25	....	....	....	....	+ 3	− 3			
	30	....	....	....	+ 6	0	− 6			
	35	....	....	....	+ 3	− 3				
	40	....	....	+ 6	− 1	− 6				
	45	....	....	+ 3	− 3					
	50	....	+ 6	− 1	− 6					
	55	....	+ 3	− 3						
	60	+ 6	− 1	− 6						
	70	− 1	− 6							
	80	− 6								
85	10	....	....	....	....	....	....	0		
	15	....	....	....	....	....	+ 3	− 3		
	20	....	....	....	....	....	0			
	25	....	....	....	....	+ 3	− 3			
	30	....	....	....	....	0				
	35	....	....	....	+ 3	− 3				
	40	....	....	....	0					
	45	....	....	+ 3	− 3					
	50	....	....	− 1						
	55	....	+ 3	− 3						
	60	....	0							
	75	− 3								

TABLE L

To reduce the numbers in Table XLIX., so as to correspond to the actual horizontal parallax of the planet.

Horizontal Parallax of the Planet.

Table XLIX. ″	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″	12″	13″	14″	15″	16″	17″	18″	19″	20″	21″	22″	23″	24″	25″	26″	27″	28″	30″	35″	Table XLIX. ″
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
3	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	3	3	3
4	0	0	0	0	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	4	4
5	0	0	0	1	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	4	4	4	4	4	5	5
6	0	0	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	4	4	4	4	4	4	5	5	5	6	6
7	0	0	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	4	4	4	4	4	5	5	5	5	5	6	6	7	7
8	0	0	1	1	1	1	2	2	2	2	3	3	3	3	3	4	4	4	4	5	5	5	5	5	6	6	6	6	7	8	8
9	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6	6	7	7	7	8	9	9
10	0	1	1	1	1	2	2	2	3	3	3	3	4	4	4	5	5	5	5	6	6	6	7	7	7	7	8	8	9	10	10
11	0	1	1	1	2	2	2	3	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7	8	8	8	8	9	9	11	11
12	0	1	1	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	7	7	7	8	8	8	9	9	9	10	10	12	12
13	0	1	1	1	2	2	3	3	3	4	4	4	5	5	6	6	6	7	7	7	8	8	9	9	9	10	10	10	11	13	13
14	0	1	1	2	2	2	3	3	4	4	4	5	5	6	6	6	7	7	8	8	8	9	9	10	10	10	11	11	12	14	14
15	0	1	1	2	2	3	3	3	4	4	5	5	6	6	6	7	7	8	8	9	9	9	10	10	11	11	12	12	13	15	15
16	0	1	1	2	2	3	3	4	4	5	5	5	6	6	7	7	8	8	9	9	10	10	11	11	11	12	12	13	14	16	16
17	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	15	17	17
18	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	18	18
19	1	1	2	2	3	3	4	4	5	5	6	7	7	8	8	9	9	10	10	11	11	12	12	13	14	14	15	15	16	19	19
20	1	1	2	2	3	3	4	5	5	6	6	7	7	8	9	9	10	10	11	11	12	13	13	14	14	15	15	16	17	20	20
21	1	1	2	2	3	4	4	5	5	6	7	7	8	8	9	10	10	11	11	12	13	13	14	14	15	16	16	17	18	21	21
22	1	1	2	3	3	4	4	5	6	6	7	8	8	9	9	10	11	11	12	13	13	14	14	15	16	16	17	18	19	22	22
23	1	1	2	3	3	4	5	5	6	7	7	8	9	9	10	11	11	12	12	13	14	14	15	16	16	17	18	18	20	23	23
24	1	1	2	3	3	4	5	5	6	7	8	8	9	10	10	11	12	12	13	14	14	15	16	16	17	18	19	19	21	24	24
25	1	1	2	3	4	4	5	6	6	7	8	9	9	10	11	11	12	13	14	14	15	16	16	17	18	19	19	20	21	25	25
26	1	1	2	3	4	4	5	6	7	7	8	9	10	10	11	12	13	13	14	15	16	16	17	18	19	19	20	21	22	26	26
27	1	2	2	3	4	5	5	6	7	8	8	9	10	11	12	12	13	14	15	15	16	17	18	19	19	20	21	22	23	27	27
28	1	2	2	3	4	5	6	6	7	8	9	10	10	11	12	13	14	14	15	16	17	18	18	19	20	21	22	22	24	28	28
29	1	2	2	3	4	5	6	7	7	8	9	10	11	12	12	13	14	15	16	17	17	18	19	20	21	22	22	23	25	29	29
30	1	2	3	3	4	5	6	7	8	9	9	10	11	12	13	14	15	15	16	17	18	19	20	21	21	22	23	24	26	30	30
31	1	2	3	4	4	5	6	7	8	9	10	11	12	12	13	14	15	16	17	18	19	19	20	21	22	23	24	25	27	31	31
32	1	2	3	4	5	5	6	7	8	9	10	11	12	13	14	15	16	16	17	18	19	20	21	22	23	24	25	26	27	32	32
33	1	2	3	4	5	6	7	8	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	25	26	28	33	33
34	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	17	18	19	20	21	22	23	24	25	26	27	29	34	34
35	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30	35	35

Digitized by Google

TABLE LI.

To change mean solar time into sidereal time.

Solar Hours.	Add. M. S.	Solar Minutes.	Add. S.	Solar Seconds.	Add. S.
1	0 9.9	1	0.2	1	0.0
2	0 19.7	2	0.3	2	0.0
3	0 29.6	3	0.5	3	0.0
4	0 39.4	4	0.7	4	0.0
5	0 49.3	5	0.8	5	0.0
6	0 59.1	6	1.0	6	0.0
7	1 9.0	7	1.2	7	0.0
8	1 18.9	8	1.3	8	0.0
9	1 28.7	9	1.5	9	0.0
10	1 38.6	10	1.6	10	0.0
11	1 48.4	11	1.8	11	0.0
12	1 58.3	12	2.0	12	0.0
13	2 8.1	13	2.1	13	0.0
14	2 18.0	14	2.3	14	0.0
15	2 27.8	15	2.5	15	0.0
16	2 37.7	16	2.6	16	0.0
17	2 47.6	17	2.8	17	0.0
18	2 57.4	18	3.0	18	0.0
19	3 7.3	19	3.1	19	0.1
20	3 17.1	20	3.3	20	0.1
21	3 27.0	21	3.5	21	0.1
22	3 36.8	22	3.6	22	0.1
23	3 46.7	23	3.8	23	0.1
24	3 56.6	24	3.9	24	0.1
		25	4.1	25	0.1
		26	4.3	26	0.1
		27	4.4	27	0.1
		28	4.6	28	0.1
		29	4.8	29	0.1
		30	4.9	30	0.1
		31	5.1	31	0.1
		32	5.3	32	0.1
		33	5.4	33	0.1
		34	5.6	34	0.1
		35	5.8	35	0.1
		36	5.9	36	0.1
		37	6.1	37	0.1
		38	6.2	38	0.1
		39	6.4	39	0.1
		40	6.6	40	0.1
		41	6.7	41	0.1
		42	6.9	42	0.1
		43	7.1	43	0.1
		44	7.2	44	0.1
		45	7.4	45	0.1
		46	7.6	46	0.1
		47	7.7	47	0.1
		48	7.9	48	0.1
		49	8.1	49	0.1
		50	8.2	50	0.1
		51	8.4	51	0.1
		52	8.5	52	0.1
		53	8.7	53	0.1
		54	8.9	54	0.1
		55	9.0	55	0.2
		56	9.2	56	0.2
		57	9.4	57	0.2
		58	9.5	58	0.2
		59	9.7	59	0.2
		60	9.9	60	0.2

TABLE LII.

To change sideral time into mean solar time.

Sideral Hours.	Subtract. M. S.	Sideral Minutes.	Subtract S.	Sideral Seconds.	Subtract S.
1	0 9.8	1	0.2	1	0.0
2	0 19.7	2	0.3	2	0.0
3	0 29.5	3	0.5	3	0.0
4	0 39.3	4	0.7	4	0.0
5	0 49.1	5	0.8	5	0.0
6	0 59.0	6	1.0	6	0.0
7	1 8.8	7	1.1	7	0.0
8	1 18.6	8	1.3	8	0.0
9	1 28.5	9	1.5	9	0.0
10	1 38.3	10	1.6	10	0.0
11	1 48.1	11	1.8	11	0.0
12	1 58.0	12	2.0	12	0.0
13	2 7.8	13	2.1	13	0.0
14	2 17.6	14	2.3	14	0.0
15	2 27.4	15	2.5	15	0.0
16	2 37.3	16	2.6	16	0.0
17	2 47.1	17	2.8	17	0.0
18	2 56.9	18	2.9	18	0.0
19	3 6.8	19	3.1	19	0.1
20	3 16.6	20	3.3	20	0.1
21	3 26.4	21	3.4	21	0.1
22	3 36.2	22	3.6	22	0.1
23	3 46.1	23	3.8	23	0.1
24	3 55.9	24	3.9	24	0.1
		25	4.1	25	0.1
		26	4.3	26	0.1
		27	4.4	27	0.1
		28	4.6	28	0.1
		29	4.8	29	0.1
		30	4.9	30	0.1
		31	5.1	31	0.1
		32	5.2	32	0.1
		33	5.4	33	0.1
		34	5.6	34	0.1
		35	5.7	35	0.1
		36	5.9	36	0.1
		37	6.1	37	0.1
		38	6.2	38	0.1
		39	6.4	39	0.1
		40	6.6	40	0.1
		41	6.7	41	0.1
		42	6.9	42	0.1
		43	7.0	43	0.1
		44	7.2	44	0.1
		45	7.4	45	0.1
		46	7.5	46	0.1
		47	7.7	47	0.1
		48	7.9	48	0.1
		49	8.0	49	0.1
		50	8.2	50	0.1
		51	8.4	51	0.1
		52	8.5	52	0.1
		53	8.7	53	0.1
		54	8.8	54	0.1
		55	9.0	55	0.2
		56	9.2	56	0.2
		57	9.3	57	0.2
		58	9.5	58	0.2
		59	9.7	59	0.2
		60	9.8	60	0.2

Digitized by Google

TABLE LIII.

This table gives the Variation of the Compass for 1871, very nearly as given in the British Admiralty chart of Curves of Equal Magnetic Variation, 1871.

Latitude.	West Longitude.																			Latitude.
	180°	170°	160°	150°	140°	130°	120°	110°	100°	90°	80°	70°	60°	50°	40°	30°	20°	10°	0°	
	Variation of the Compass.																			
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
60 N	16 E	21 E	25 E	29 E	32 E	33 E	31 E	27 E	19 E	4 W	32 W	49 W	53 W	54 W	51 W	47 W	39 W	30 W	22 W	60 N
58	15	20	24	27	30	30	29	25	18	0	26	42	49	50	48	45	38	29	21	58
56	15	19	23	26	28	29	27	24	17	2 E	21	36	45	47	46	43	36	28	21	56
54	14	18	22	24	26	27	26	23	17	4	17	31	40	44	43	40	34	26	20	54
52	14	18	21	23	25	25	24	22	16	5	13	27	36	40	41	38	33	25	20	52
50	14	17	20	22	23	24	23	21	15	6	10	22	31	36	38	36	31	24	19	50
48	14	17	19	21	22	22	22	20	15	6	7	20	28	33	35	34	29	24	19	48
46	14	16	18	20	21	21	21	18	14	7	6	17	25	31	33	32	28	23	18	46
44	13	16	18	19	20	20	19	17	13	7	4	14	22	28	32	30	27	22	18	44
42	13	15	17	18	19	19	18	16	13	7	2	11	20	26	29	29	26	22	18	42
40	13	15	16	17	18	18	17	15	12	7	1 W	9	18	24	27	27	25	21	17	40
38	13	14	15	16	17	17	16	15	12	7	0	8	15	22	25	26	24	21	17	38
36	13	14	15	15	16	16	15	14	11	7	1 E	6	13	20	24	25	23	20	17	36
34	12	14	14	15	15	15	14	13	11	7	1	5	11	18	22	24	22	20	17	34
32	12	13	14	14	14	14	13	12	10	7	2	4	10	16	21	23	22	19	16	32
30	12	13	13	13	13	13	12	12	10	7	3	3	9	14	20	22	21	19	16	30
28	12	12	12	12	12	12	12	11	10	7	3	2	7	13	18	21	20	19	16	28
26	12	12	12	11	11	11	11	11	9	7	3	1 W	6	11	17	20	20	19	16	26
24	11	12	11	11	10	10	10	10	9	7	4	0	5	10	16	20	20	18	16	24
22	11	11	10	10	10	10	10	9	9	7	4	1 E	4	9	15	19	20	18	17	22
20	11	11	10	9	9	9	9	9	9	7	4	1	3	8	14	19	20	18	17	20
18	10	10	9	8	8	8	8	8	8	7	5	2	1 W	7	13	18	20	18	17	18
16	10	10	9	8	7	7	8	8	8	7	5	2	0	6	12	18	19	18	17	16
14	10	9	8	7	7	7	7	8	8	7	5	3	0	5	11	17	19	19	17	14
12	10	9	8	7	6	6	7	7	8	8	6	3	1 E	4	11	17	19	19	17	12
10	9	9	7	6	6	6	6	7	8	8	6	4	1	3	10	16	20	19	18	10
8	9	8	7	6	5	5	6	7	8	8	7	4	2	2	9	16	20	19	18	8
6	9	8	7	6	5	5	6	6	8	8	7	4	2	2	9	16	20	19	18	6
4	9	8	7	5	5	5	5	6	8	8	7	5	2	2	9	16	20	20	19	4
2 N	9	8	7	5	5	5	5	6	8	9	8	5	2	1	8	16	20	20	19	2 N
0	9	8	7	5	5	5	5	6	8	9	8	6	3	1	8	15	20	21	20	0
2 S	9	8	7	5	5	5	5	6	8	9	8	6	3	1	8	15	20	21	21	2 S
4	9	8	7	5	5	5	5	7	8	9	9	6	3	1 W	8	15	20	22	21	4
6	9	8	7	5	5	5	6	7	9	10	9	7	3	0	8	15	20	23	22	6
8	9	8	7	6	5	5	6	7	9	10	10	7	4	0	8	15	20	23	23	8
10	9	8	7	6	5	6	6	7	9	10	10	8	4	0	7	14	20	24	24	10
12	9	8	7	6	6	6	6	8	9	11	11	8	4	0	7	14	19	24	25	12
14	10	9	8	7	6	6	7	8	10	11	11	9	5	0	7	14	19	24	25	14
16	10	9	8	7	7	7	7	8	10	12	11	9	5	0	6	13	19	24	26	16
18	10	9	8	7	7	7	7	9	10	12	12	10	6	1 E	6	13	18	24	27	18
20	10	9	8	8	7	7	8	9	11	13	12	10	6	1	5	12	18	23	27	20
22	11	10	9	8	8	8	8	9	11	13	13	11	7	1	5	12	18	23	27	22
24	11	10	9	8	8	8	8	10	12	14	14	12	7	2	5	11	17	23	27	24
26	11	10	9	9	8	8	9	10	12	14	15	12	8	3	4	11	17	22	27	26
28	12	11	10	9	8	9	9	10	12	15	15	13	9	3	4	10	16	22	26	28
30	12	11	10	9	9	9	9	11	13	15	16	14	9	4	3	10	16	21	26	30
32	13	11	10	9	9	9	10	11	13	16	16	15	10	4	2	9	15	21	26	32
34	13	12	11	10	9	9	10	12	14	16	17	15	11	5	2	8	15	20	25	34
36	14	12	11	10	10	10	10	12	14	17	18	16	11	6	1	8	14	19	24	36
38	14	13	11	10	10	10	11	13	15	17	18	17	12	6	1 W	7	13	19	24	38
40	15	13	12	11	10	10	11	13	16	18	19	17	13	7	0	7	13	18	23	40
42	15	14	12	11	11	11	12	14	17	19	20	18	14	7	1 E	6	12	18	23	42
44	16	14	13	12	11	11	12	14	17	20	21	19	14	8	2	5	12	17	22	44
46	16	15	13	12	12	12	13	15	18	21	22	19	15	9	2	4	11	16	22	46
48	17	15	14	13	12	12	14	16	19	22	22	20	16	9	3	4	10	16	21	48
50	18	16	14	13	13	13	14	17	20	23	23	21	16	10	4	3	9	15	20	50
52	18	17	15	14	13	14	15	18	21	24	24	21	17	11	4	2	9	14	20	52
54	19	17	16	15	14	14	16	19	23	25	25	22	17	12	5	1 W	8	14	19	54
56	19	18	17	15	15	15	18	21	24	26	26	23	18	12	6	0	7	13	18	56
58	20	19	18	17	16	17	19	22	25	27	26	24	19	13	7	0	6	12	17	58
60 S	21 E	20 E	19 E	18 E	17 E	18 E	20 E	24 E	27 E	28 E	27 E	24 E	19 E	14 E	7 E	1 E	5 W	11 W	17 W	60 S
Latitude.	180	170	160	150	140	130	120	110	100	90	80	70	60	50	40	30	20	10	0	Latitude.
	West Longitude.																			

Digitized by Google

TABLE LIII.

This table gives the Variation of the Compass for 1871, very nearly as given in the British Admiralty chart of Curves of Equal Magnetic Variation, 1871.

Latitude.	East Longitude.																			Latitude.
	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°	140°	150°	160°	170°	180°	
	Variation of the Compass.																			
°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
60 N	22 W	15 W	9 W	2 W	4 E	8 E	11 E	12 E	12 E	10 E	5 E	0	3 W	6 W	4 W	0	5 E	10 E	16 E	60 N
58	21	15	9	3	3	8	10	11	11	9	4	0	4	6	4	0	5	10	15	58
56	21	15	9	3	2	7	9	10	10	8	4	1 W	4	6	4	0	4	10	15	56
54	20	14	9	3	2	6	9	10	10	8	4	1	4	6	5	1 W	4	9	14	54
52	20	14	9	4	1 E	5	8	9	9	7	3	1	4	6	5	1	4	9	14	52
50	19	14	9	4	0	4	7	8	9	7	3	1	4	6	5	1	4	10	4	50
48	19	14	9	4	0	3	6	8	8	7	3	1	4	6	5	1	4	10	14	48
46	18	13	9	4	1 W	3	5	7	8	7	3	1	4	6	5	1 W	4	10	14	46
44	18	13	9	5	1	2	5	7	7	7	3	1 W	4	6	5	0	5	10	13	44
42	18	13	9	5	2	2	4	6	7	6	3	0	4	6	5	0	5	10	13	42
40	17	13	9	5	2	1 E	3	5	6	6	3	0	3	6	4	0	5	10	13	40
38	17	13	9	5	2	0	3	4	6	6	3	0	3	5	4	0	5	10	13	38
36	17	13	10	6	2	0	2	4	5	5	3	0	3	5	4	0	5	10	13	36
34	17	13	10	6	3	0	2	3	4	5	3	0	2	4	3	1 E	6	10	12	34
32	16	13	10	6	3	1 W	1	3	4	4	3	0	2	4	2	1	6	10	12	32
30	16	13	10	6	3	1	1 E	2	3	4	3	1 E	2	3	2	1	6	10	12	30
28	16	13	10	6	3	1	0	2	3	3	3	1	1	3	1	2	6	10	12	28
26	16	14	10	7	4	1	0	1	2	3	3	1	1	2	1	2	6	10	12	26
24	16	14	10	7	4	2	0	1	2	3	3	1	1 W	2	1 W	2	6	10	[illegible]	24
22	17	14	11	7	4	2	0	1	2	2	2	1	0	1	0	3	7	10	11	22
20	17	14	11	7	4	2	0	1	2	2	2	2	0	1	0	3	7	10	11	20
18	17	15	11	8	4	2	1 W	1 E	1	2	2	2	0	1 W	1 E	3	7	10	10	18
16	17	15	12	8	5	2	1	0	1	2	2	2	0	0	1	4	7	11	10	16
14	17	15	12	8	5	3	1	0	1	2	2	2	1 E	0	1	4	7	11	10	14
12	17	16	12	9	5	3	1	0	1	2	2	2	1	1 E	2	4	7	11	10	12
10	18	16	13	9	6	3	1	0	1	2	2	2	1	1	2	5	7	9	9	10
8	18	16	13	10	6	4	2	0	1	2	2	2	1	1	3	5	8	9	9	8
6	18	17	14	10	7	4	2	0	1	1	2	2	1	2	3	5	8	9	9	6
4	19	17	14	11	7	4	2	0	1	1	2	2	1	2	3	5	8	9	9	4
2 N	19	17	15	11	8	5	2	1 W	1 E	1	1	2	2	2	3	5	8	9	9	2 N
0	20	18	16	12	8	5	3	1	0	1	1	1	2	2	3	6	8	9	9	0
2 S	21	19	16	13	9	6	3	1	0	1	1	1	1	2	4	6	8	9	9	2 S
4	21	19	17	14	10	6	4	2	0	1 E	1	1	1	2	4	6	8	9	9	4
6	22	20	17	14	10	7	4	2	0	0	1	1	1	2	4	6	8	9	9	6
8	23	21	18	15	11	7	5	2	1 W	0	1 E	1 E	1	2	4	6	8	9	9	8
10	24	22	19	16	12	8	5	3	1	0	0	0	1	2	4	7	8	9	9	10
12	25	23	20	17	13	9	6	4	2	1 W	0	0	1 E	2	4	7	9	9	9	12
14	25	24	21	18	14	10	7	4	3	2	1 W	1 W	0	2	5	7	9	10	10	14
16	26	25	22	19	15	10	8	5	4	3	2	1	0	2	5	7	9	10	10	16
18	27	26	24	20	16	12	8	6	4	3	2	2	1 W	2	5	8	9	10	10	18
20	27	27	25	21	17	13	10	7	5	4	3	2	1	1	5	8	10	10	10	20
22	27	27	26	22	19	14	11	8	7	6	4	3	1	1	5	8	10	11	11	22
24	27	28	27	24	20	16	12	10	8	7	5	3	1	1	5	8	10	11	11	24
26	27	28	27	25	21	17	14	11	10	8	7	4	2	1	5	9	11	12	11	26
28	26	29	28	26	22	19	15	12	11	10	8	5	2	1 E	6	9	11	12	12	28
30	26	29	29	27	24	20	17	14	12	12	9	6	3	0	6	9	11	13	12	30
32	26	29	29	28	25	22	19	16	14	13	11	7	3	0	6	10	12	13	13	32
34	25	29	30	29	27	23	21	18	17	15	12	8	4	0	6	10	12	13	13	34
36	24	28	30	30	28	25	23	20	19	17	14	9	4	0	6	10	13	14	14	36
38	24	28	31	31	30	27	24	22	21	19	15	10	5	0	6	11	13	14	14	38
40	23	28	31	32	31	28	26	24	22	20	17	12	6	0	7	11	14	15	15	40
42	23	27	31	32	32	30	28	26	24	23	19	13	7	1 W	7	11	14	15	15	42
44	22	27	31	33	33	31	29	27	26	25	20	15	8	1	7	12	15	16	16	44
46	22	26	31	33	34	32	31	29	28	27	22	16	9	1	7	12	15	17	16	46
48	21	26	30	34	34	34	32	31	30	29	25	17	10	2	7	12	16	17	17	48
50	20	25	30	34	35	35	34	33	32	31	27	19	11	2	7	13	16	18	18	50
52	20	25	30	34	36	36	36	35	35	34	29	21	12	2	7	13	17	19	18	52
54	19	24	29	34	37	37	38	38	38	37	32	23	14	3	7	14	18	19	19	54
56	18	24	29	34	37	38	39	40	41	40	34	25	16	4	7	14	19	20	19	56
58	17	23	29	34	37	39	40	43	44	43	38	28	18	6	7	15	20	21	20	58
60 S	17 W	22 W	28 W	34 W	37 W	39 W	42 W	45 W	46 W	45 W	41 W	31 W	20 W	7 W	6 E	15 E	21 E	22 E	21 E	60 S
Latitude.	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	Latitude.
	East Longitude.																			

Digitized by Google

TABLE LIV

Latitudes and Longitudes.

This table contains the Latitudes and Longitudes of the most remarkable Harbors, Islands, Shoals, Capes, &c.. in the world, founded on the latest and most accurate astronomical observations, surveys, and charts.

The longitudes are reckoned from the meridian of Greenwich.

I. *Coast of the United States of America.*

		Lat.		Long.	
		D.	M.	D.	M.
Maine.	ENTRANCE of St. Croix River	45	00 N	67	02 W
	Island of Campo Bello, (N. point,)	44	57	66	55
	Wolf Islands, (northernmost,)	44	57.5	66	43
	Quoddy Head light	44	47.5	66	58
	Grand Manan, N. E. head	44	45	66	45
	——— S. W. head	44	34	66	53
	Libby Island light, entrance Machias Bay	44	32.5	67	22
	Titmanan light	44	22	67	52
	Mount Desert Rock, (light-house,)	43	58	68	08.5
	Isle au Haut	43	59	68	34.5
	Castine Fort,	44	22.5	68	48.5
	Matinicus Island lights	43	47.1	68	51
	Wooden Bald Rock	43	50	68	46
	Manhegan Island light	43	44	69	15
	Penmaquid Point light	43	48	69	29
	Bantum Ledge	43	42	69	35
	Seguin Island light	43	42.2	69	45.2
	Brunswick College	43	54.	69	57.4
	Cape Small-Point	43	46.7	69	50.4
	Cashe's Ledge, (shoalest part 26 feet,)	42	56	68	51.5
	PORTLAND light-house	43	37.4	70	12.2
	Cape Elizabeth, (W. light)	43	33.8	70	11.8
	Wood Island light, entrance Saco River	43	27.4	70	19.4
	Agamenticus Hills, Tri. Pt.	43	13.4	70	41.2
	Cape Porpoise	43	21.4	70	25.2
	Bald Head	43	13.2	70	34.4
	Cape Neddock Nubble	43	10	70	35.6
N. Hamp.	Boon Island light	43	07.3	70	28.3
	PORTSMOUTH { Whaleback light }	43	03.5	70	41.5
	Isle of Shoals, (White Island light,)	42	58	70	37.5
	Portsmouth, Ft. Constitution	43	04.5	70	42.2
	Great Boar's Head	42	55.1	70	47.4
Massachusetts.	NEWBURYPORT W. lt. on Plum Island	42	48.4	70	48.8
	Ipswich entrance light	42	41.1	70	45.8
	Squam light	42	39.7	70	40.6
	CAPE ANN (Thatcher's Island) N. light	42	38.3	70	34.2
	Eastern point Cape Ann Harbor light	42	34.8	70	39.5
	Light-house on Baker's Island	42	32.2	70	46.8
	Beverly Spire	42	43.0	70	52.4
	SALEM, Tall spire	42	31.2	70	53.6
	Marblehead Black-top ch'h	42	30.4	70	50.5
	Nahant Point, N. E. point of Boston Harbor, Hotel	42	25.1	70	54.0
	Boston light-house†	42	19.6	70	53.1
	BOSTON, State-House	42	21.5	71	03.5
	Cambridge Observatory	42	22.9	71	07.4
	Scituate light	42	12.3	70	42.6
	Plymouth lights, south	42	00.2	70	35.7
	Race Point light	42	03.7	70	14.3
	CAPE COD light	42	02.4	70	03.3
	Chatham South light	41	40.2	69	56.6
	Monomoy Point light	41	33.5	69	59.3
	Shoal of George's.				
	Great Shoal, S. E. point	41	33	67	39
	——— N.W. point	41	44.7	67	47.5
	Western Shoals { From	41	39.6	67	49.4
	Western Shoals { To	41	35.9	67	53
	North Shoal	41	46.4	67	48
	Third Shoal	41	46.5	67	28.2
	East Shoal	41	43	67	22.2
	NANTUCKET light, (Great Point,)	41	23.4	70	02.4
	Sancoty Head	41	17.0	69	57.6
	Nantucket South Shoal*	41	04.2	69	51.4
	Cape Poge, (Vineyard,) Lt	41	25.2	70	26.7
	Cutterhunk Island light	41	24.8	70	56.7
	Gay-Head light-house	41	20.9	70	47.8
	Noman's Land Triang Pt.	41	15.2	70	48.5
	New Bedford Court-House	41	38.1	70	56.2
	——— light-house.	41	35.5	70	53.7
	Seaconnet Point	41	27	71	13.5
R. Island.	NEWPORT, Spire	41	29.2	71	18.5
	Rhode Island light-house, (Beaver Tail light,)	41	26.9	71	23.6
	Providence Baptist Church	41	49.6	71	24.2
	Point Judith light	41	21.6	71	28.6
	Block Island light	41	13.4	71	34.2
	——— S. E. point	41	08	71	34
Connecticut.	Watch Hill light-house	41	18.2	71	51.2
	Little Gull Island light	41	12.3	72	06.1
	New London light-house.	41	19.0	72	05.1
	MONTAUK POINT (E. end Long Island) light-h.	41	04.2	71	51.1
	Falkner's Island light	41	12.7	72	38.9
	NEW HAVEN light	41	14.9	72	53.9
	Stratford Point light	41	09.1	73	05.9
N. York.	Old Field Point light	40	58.6	73	06.8
	Eaton's Point light	40	57.2	73	23.4
	NEW YORK, City Hall.	40	42.7	74	00.1
	Sandy Hook light	40	27.7	73	59.8
N. Jer.	Neversink lights	40	23.7	73	58.8
	Barnegat Light Ho	39	46.0	74	00.0
	Great Egg Harbor	39	19	74	35
	Cape May light	38	55.8	74	57.3
Penn.	Cape Henlopen light-house	38	46 6	75	04 7
	Egg Island light	39	10.5	75	08.0
	PHILADELPHIA St. Ho	39	50.9	75	08.7
Virginia.	Smith's Island light	37	07.8	75	52.2
	Cape Charles	37	07.3	75	57.9
	Cape Henry light	36	55 5	76	00.2
	Norfolk	36	50.7	76	17
	Old Point Comfort	37	00.0	76	18.1
	Yorktown	37	13	76	34
	Petersburgh	37	14	77	24
	RICHMOND, Capitol	37	32.2	77	25.8
Maryl.	WASHINGTON City	38	53.3	77	00.2
	BALTIMORE W. Mt.	39	17.8	76	36.6
	Annapolis, Md. St. Ho.	38	58.7	76	29.1
N. Car.	Currituck Inlet	36	23	75	55
	CAPE HATTERAS	35	15.2	75	30.9
	Deep soundings off ditto.	35	06		
	Ocracock Inlet	35	06.5	75	58.9

* New South Shoal, 40° 58' 0 N., 69° 51' 5 W.

† Minot's Ledge Light, S. E. ¼ E. from Boston Light.

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat.	Long.
		D. M.	D. M.
N. Carolina.	CAPE LOOKOUT, Lt..	34 37.3	76 30.7
	Deep soundings off do....	34 28	
	Old Topsail Inlet........	34 41	76 40
	Beaufort.................	34 43	76 40
	Wilmington	34 14	77 58
	Brunswick	34 02	77 58
	Smithville...............	33 54	78 01
	New Inlet South point...	35 41.1	75 28.5
	CAPE FEAR Bald Hd L'	33 52.3	77 59.8
	Deep soundings off do....	33 35	
South Carolina.	GEORGETOWN Church	33 22	79 18
	——— light-house	33 13.3	79 10.7
	Cape Roman..............	33 01.1	79 22 2
	CHARLESTON, (Fort Pinckney,)........	32 46 4	79 54.4
	——— light-house	32 41.9	79 52.5
	North Edisto River......	32 33.5	80 10.7
	BEAUFORT, (S. C.)....	32 27	80 40
	Port Royal Entrance,	32 04.5	80 37.7
Georgia.	Tybee light..............	32°01.4	80 50.6
	SAVANNAH Exchange..	32 05	81 05.2
	St. Catharine s Island, North point...........	31 41.5	81 11
	Sapello Bar St. Cath. Is.	31 31	81 13
	Doboy Bar Light.......	31 21	81 18.6
	Light on St. Simon's Island, S. point..........	31 07	81 26
	Brunswick	31 06	81 31
	St. Andrew's Bar..........	30 53	81 20
	Cumberland Island S. point..............	30 43	81 28
	Amelia Island, S. pt.....	30 30	81 26
East Coast of Florida.	River St. John's Light...	30 20.5	81 24.5
	St. Augustine light-house	29 52.3	81 20
	Cape Carnaveral Light...	28 28	80 34
	Breakers, S. E. point	28 24	80 30
	Las Tortulas, or Hummocks	27 35	80 30
	Hillsborough Island, N. p.	27 32	80 18
	——— S. p.	27 14	80 11
	Mount Pelado, or Bald Head	27 01	80 11
	Grenville's Inlet	26 47	80 02
	Cooper's Hill	26 42	80 03
	Sand Hills...............	26 32	80 03
	New Inlet	26 18	80 00
	Middle River	26 08	80 00
	CAPE FLORIDA light.	25 40	80 09.4
	Carrysfort Light	25 13.2	80 12.7
South Coast of Florida.	Key Tavernier	24 59	80 30
	Old Metacumbe, S. W. pt.	24 52	80 41
	Cayo Sombrero..........	24 37	81 07
	Looe Key	24 34	81 24
	Samboes Keys, (eastern,).	24 29	81 40
	Key West, Light........	24 33.0	81 48.1
	Sand Key, Light (old)....	24 27.2	81 52.7
	Tortugas Islands and Banks, N. E. point.....	24 41	82 47
	——— N. W. point.....	24 40	82 53
	——— S. E. point.....	24 33.5	82 53.2
	——— S. W. point.....	24 31	83 07
	Bush Key light	24 36.7	82 54
	Key Vacas..............	24 42	81 05
	Key Axi................	24 57	81 07
	Cape Sable	25 06	81 09
	Cape Romano...........	25 51	81 57
	Boca Grande, entrance Bay Carlos...........	26 43	82 23

		Lat.	Long.
		D. M.	D. M.
West Coast of Florida.	Tampa Bay, Egmont Key	27 36 N	82 45 W
	Anclote Keys............	28 17 5	82 54.3
	St. Mark's light-house....	30 04.5	84 10.6
	South-west Cape	29 52	84 22
	Dog Island light	29 46.5	84 34
	Cape St. George, Light...	29 35	84°58.5
	Cape St. Blas...........	29 39.6	85 16
	St. Joseph's Bay, entrance	29 51.6	85 23
	St. Andrew's Bay, entrance Main Pass......	30 03	85 37.7
	St. Rosa's Bay, entrance .	30 24	86 31
	PENSACOLA, town....	30 25	87 11.5
	——— light.....	30 21	87 16.9
Alabama.	Mobile Point, light......	30 13.8	88 00 5
	——— bar, outer...	30 09	88 01
	MOBILE Barton's Acad'y	30 41.4	88 01.9
	Massacre Island, W. pt...	30 12	88 22
	Ship Island, W. Light....	30 12.9	88 57.0
Louisiana.	Chandeleur Islands, N. point, Light...........	30 03	88 51
	——— S. pt. Palos Island.	29 44	88 51
	Key Breton, N. E. pt.....	29 29	89 07
	MISSISSIPPI River, Pass a l'Outre	29 14	89 00
	——— Balize......	29 08.5	89 01.4
	——— S. E. Pass..	29 06	88 57
	——— S. Pass....	28 59.7	89 07.4
	——— S. W. Pass.	28 58.5	89 20
	NEW ORLEANS......	29 57.5	90 00
	Barataria	29 17.5	90 10
	Bayou la Fourche........	29 06	90 09
	Timbalier Island, (Tonbalier,) N. W. point......	29 05	90 23
	Racoon point...........	29 03	90 57
	Bayou Decartes, entrance	29 10	91 04
	Point au Fer Light......	29 19.5	91 20
	Rabbit Island...........	29 29	91 36
	Sabine River, entrance...	29 40.6	93 49
	Galveston, entrance......	29 20.5	94 45

II. *Islands in the West Indies.*

		Lat.	Long.
	TRINIDAD.	D. M.	D. M.
Windward Islands.	——— Spanish Town, (fort,)	10 39 N	61 32 W
	——— Icacque Point	10 04	61 57
	——— Point Galiote.	10 10	61 00
	——— Point Galera .	10 50	60 56
	Tobago, N. E. point......	11 20	60 27
	——— S. W. point.....	11 06	60 46
	Grenada, Point Salinus, S. W. pt.	12 00	61 49
	Grenada Bank, ...	11 55	61 57
	Barbadoes, S. point.......	13 03	59 37
	——— Engineers' wharf.	13 04	59 38
	——— N. point......	13 20	59 41
	St. Vincent's, Kingston ..	13 12	61 16
	——— S. point	13 09	61 14
	St. Lucia, N. point	14 06	60 57
	——— S. point	13 41	60 54
	Martinico, S. point	14 27	60 55
	——— Diamond Rock	14 26.6	61 02.7
	——— Port Royal....	14 36	61 04.2
	——— Macouba Pt. ..	14 55	61 09
	Dominica, Roseau	15 18	61 25
	——— N. point	15 38	61 26

Digitized by Google

TABLE LIV

Latitudes and Longitudes.

		Lat. D.	Lat. M.	Long. D.	Long. M.
Windward Islands.	The Saint's Island, W. pt.	15	51 N	61	38W
	Mariegalante, S. point	15	52	61	18
	Guadaloupe, S. W. pt.	15	57	61	44
	—— N. W. pt.	16	20	61	51
	—— N. E. pt.	16	30	61	29
	—— Point Chateau, S. E. pt.	16	13	61	12
	Deseada,	16	20	61	06
	Antigua, E. point	17	05	61	45
	—— Fort James	17	08	61	52
	Montserrat, N. E. point	16	48	62	12
	Redondo Island	16	56	62	25
	Nevis, Charlestown	17	08.7	62	37.9
	St. Christopher's or St. Kitt's, N. point	17	24	62	50
	—— Basse Terre	17	17.7	62	42.2
	St. Eustatia, Town	17	29	63	00
	Saba	17	41	63	14
	Aves or Birds' Island	15	40	63	39
	Barbuda, N. pt.	17	47	62	02
	St. Bartholomew, S. pt.	17	53.5	62	56.9
	St. Martin's, Marigot Fort	18	05	63	03
	Anguilla, S. W. pt.	18	10	63	13
	Anguilleta, N. E. pt.	18	18	62	58
	Prickly Pear	18	20	63	23
	Sombrero	18	38	63	27.4
Virgin Islands.	St. Croix or St. Cruz, observatory	17	44.5	64	40.7
	—— S. W. pt.	17	42	64	48
	Anegada, S. point of shoal	18	32	64	13
	—— W. point	18	44	64	20
	Virgin Gorda, E. pt	18	30	64	21
	Tortola, E. point	18	27	64	36
	—— W. point	18	25	64	46
	St. John's	18	18	64	42
	St. Thomas, Fort Christian	18	21	64	55.3
	Bird Key	18	15	64	55
	Serpent Island, E. part	18	19	65	21
	Crab Island, E. part	18	10	65	19
Porto Rico.	Cape St. John, or N. E. pt.	18	24	65	39
	PORTO RICO, St. Augustine's Battery, western turret	18	29	66	07.1
	Point Bruquen, or N. W. p.	18	31	67	08
	Point St. Francisco	18	21	67	15
	Cape Roxo, or S. W. point	17	57	67	08
	Caxa de los Muertos	17	50	66	35
	Point Coamo	17	55	66	30
	Cape Mala Pasqua, or S. E. pt.	17	59	65	52
St. Domingo, or Hispaniola.	Mona Island, E. pt.	18	07	67	47
	Monito Island	18	11	67	52
	Zacheo or Dessecho Isl.	18	24	67	27
	Cape Engano	18	35	68	20
	Saona Island, E. pt.	18	12	68	30
	St. Catherine's Island	18	18	69	00
	St. Domingo, Light	18	28	69	52.5
	La Catalina	18	08	70	11
	Cape Beata	17	39	71	33
	Altavela Rock	17	28	71	39 5
	Cape Jaquemel	18	10	72	33
	Island Vacca (a Vache)	18	04	73	34
	Point Gravois	18	01	73	53
	Cape Tiberon	18	20	74	20

		Lat. D.	Lat. M.	Long. D.	Long. M.
St. Domingo, or Hispaniola.	Navaza Island	18	24 N	75	00W
	Cape Donna Maria	18	37	74	23
	Jeremie	18	37	74	03
	Caymito	18	39	73	43
	Petit Guave	18	24	72	50
	Leogano	18	30	72	33
	PORT-AU-PRINCE	18	33	72	16.3
	Isle Gonave, S. E. part	18	40	72	45
	—— N. W. part	18	57	73	13
	Point St. Mark	19	02	72	47
	St. Nicola Mole	19	49.5	73	·9.1
	Tortugas, E. point	20	02	72	31
	CAPE HAYTI CITY,	19	46.4	72	11.2
	Shoal off Monte Christe	20	02	71	42
	Monte Christe	19	54	71	34
	Grange Point	19	54	71	36
	Point Isabella	19	59	71	10.5
	Old Cape François	19	40	69	53
	Cape Samana	19	10.2	69	15.4
	Cape Raphael	19	04	68	52
Jamaica.	Morant, E. point	17	56	76	11
	KINGSTON	17	58	76	46
	Port Royal, Fort Charles	17	56	76	50.5
	Portland Point	17	43	77	11
	Pedro Bluffs	17	52.5	77	45
	Black River	18	02	77	51
	Savannah la Mar	18	12.3	78	08.5
	Cape Negril, S. point	18	15	78	24
	—— N. point	18	22.5	78	23
	Montego Bay	18	29	77	56
	Falmouth	18	28	77	41
	St. Ann's	18	27	77	15
	Port Maria	18	22	76	54
	Arnatta Bay	18	16	76	45
	N. E. point	18	09	76	20.5
	Morant Keys, or Las Panas	17	25	75	59
	Pedro Shoals.				
	—— Portland R., N. E. p.	17	07.5	77	28
	South Key	16	57	77	53
	Rock 5 feet above water	16	48	78	15
	N. pt. Pedro Shoal	17	36	78	54
	Formigas Shoal, N. E. p.	18	35	75	50
	—— S. W. p.	18	27	76	00
	Little Cayman, S. W. p.	19	36	80	14
	Caymanbrack, E. p.	19	44	79	45
	Grand Cayman, E. point	19	20	81	10
	Fort George, W. end	19	14	81	24
	Swan Islands, E. pt.	17	25	83	51
	New shoal, (Sandy Key,)	15	52	78	33
South side of Cuba.	Cape Mayze	20	15	74	06
	Port Negra	20	06	74	13
	Point, entr. Cumberland Harbor	19	54	75	16
	ST. JAGO DE CUBA, Light	19	58	75	52
	Tarquin's Peak	20	02	76	51
	Cape Cruz	19	50	77	45
	Manzanillo	20	20	77	11
	Key Breton	21	4	79	22
	Trinidad River	21	43	80	00
	Bay Xagua. River Vigia	22	02	80	42
	Stone Keys	21	5-	81	15

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat. D.	Lat. M.	Long. D.	Long. M.
South side of Cuba.	Los Jardinellos, S. E. point of the Bank	21	31 N	81	17 W
	Canal del Rosario	21	35	81	51
	Isle Pines, E. pt.	21	40	82	23
	——— S. W. pt.	21	22	83	00
	Indian Keys, N. W. pt.	21	52	83	13
	Key St. Philip, E. pt.	21	58	83	22
	Point Piedras	22	01	83	55
	Cape Corrientes	21	44	84	33
	Cape St. Antonio	21	50	84	59
	Sancho Pedro Shoal	22	01	85	02
	Shoal discovered in 1797	22	06	85	02
	Los Colorados, S. W. pt.	22	09	84	48
	——— N. E. pt.	23	00	83	08
North side of Cuba.	Hill Guajibon	22	48	83	24
	Bay Honda	23	01	83	13
	Port Cabanas	23	02.5	82	59
	Mariel	23	03	82	47
	HAVANA (the Moro)	23	09	82	22
	Cape Escondido	23	08	81	51
	Point Guanos	23	08	81	44
	Pan of Matanzas	23	02	81	46
	MATANZAS	23	03	81	40
	Point Yeacos	23	13	81	10
	Stone Key off do.	23	14.5	81	07
	Key Cruz del Padre	23	18	80	55
	Las Cabezas	23	16	80	36
	Nicholas Shoal	23	14	80	19
	Key Verde	23	09	80	14
	Key Carenero	22	52	79	49
	Key Francis, E. p.	22	40	79	13
	Key William, northern	22	34	78	45
	Pt. St. Juan	22	19	78	57
	Centre of Key Coco, S. side Bahama channel	22	29	78	20
	Key Point Paredon, do.	22	30	78	05
	The Barrel	22	25	77	56
	Cayo Confites	22	11	77	41
	Cayo or Key Verde	22	06	77	38
	Guajara, N. W. pt.	21	55	77	30
	Point Maternillos	21	41	77	08
	Neuvitas	21	36	77	03.3
	Point de Mulas	21	05	75	31
	Tanamo	20	44.5	75	12.2
	Key Moa	20	43	74	53
	Point Guarico	20	39	74	41
	Baracoa	20	21	74	30.2
Caycos Islands.	N. pt. Nativity Bank, or E. Reef	20	12	68	46
	Superb Shoal	20	58	69	00
	Silver Key, S. E. end	20	14	69	32
	——— N. E. do.	20	35	69	17
	——— N. do.	20	55	69	52
	Square Handkerchief				
	——— N. E. point	21	07	70	26
	——— S. E. point	20	49	70	23
	——— S. W. point	20	55	70	56
	*Turk's Island, N. p. Grand Turk	21	32	71	10
	——— Salt Key	21	20	71	14
	——— Sand Key	21	11.5	71	16
	——— Endymion's Rocks	21	07	71	19
	Great Caycos Isl., Swimmer's Shoal	21	05	71	32
	——— N. E. p., or Shoal St. Philip	21	42.5	71	25
	——— N. W. part	21	53	72	22

		Lat. D.	Lat. M.	Long. D.	Long. M.
Caycos Islands.	North Caycos, middle	21	56 N	72	00 W
	Booby Rocks, off do.	21	58	72	00
	Providence Caycos, N. W. p.	21	50	72	20
	West Caycos, S W. p.	21	37.5	72	30
	French Key	21	30	72	14
	South Point Shoal	21	02.5	71	50
Passage Islands.	Great Inagua, or Heneaga, N. E. p.	21	20	73	00
	——— S. E. p.	20	55	73	08
	——— S. W. p.	20	55	73	38
	——— N. W. p.	21	09	73	40
	Little Heneaga, E. p.	21	29	72	55
	——— W. p.	21	29	73	06
	Hogsties, or Corrolaes	21	40	73	48
	Lookout Bank, (Cuidado)	21	57	72	55
	Mayaguana, E. reef	22	20	72	40
	——— N. do.	22	32	73	09
	——— S. W. do.	22	22	73	11
	E. point French Keys, or Isle Planas	22	41	73	27
	Miraporvos, S. Key	22	05	74	31
	Castle Island, or S. Key	22	07	74	20
	Fortune Island, S. W. pt.	22	32	74	23
	North Key, Bird Island	22	49.5	74	24
	Crooked Island, W. pt.	22	48.5	74	23
	Acklin's Island, N. E. pt.	22	44	73	51
	Atwood's Keys, or Island Samana, E. p.	23	05	73	37
	——— W. p.	23	05	73	48
	Rum Key, E. pt.	23	41	74	46
	Watland's Island, N. E. pt.	24	08	74	25
	——— S. W. pt.	23	55	74	32
	Conception, or Little Island	23	50	75	05
	St. Salvador, or Guanhari, S. E. pt.	24	09	75	18
	——— N. pt.	24	42	75	43
	Little St. Salvador, N. pt.	24	37	75	55
	Eleuthera, or Hetera Island, S. pt.	24	37	76	08
	——— N. pt.	25	34	76	43
	——— Point Palmeto.	25	09	76	08
	Harbor Island	25	30	76	38
Great Bahama Bank.	New Providence light-h., NASSAU	25	05.2	77	21.2
	——— E. pt.	25	02	77	16
	——— W. pt.	25	01	77	35
	Andros Islands, S. pt.	23	44	77	38
	——— N. pt.	25	10	78	02
	Berry Islands,	25	25	77	44
	Stirrup Key	25	49	77	53
	Blackwood's Bush	25	27	78	03
	Little Isaac, (eastern)	25	8.5	78	51.3
	Great Isaac	26	02	79	06.3
	Bemini Island, southern fresh water Key	25	43	79	19
	Gun Key light	25	34	79	18.4
	Cat Key	25	31	79	17
	Riding Rocks, South	25	14.5	79	09
	Orange Keys, N.	24	57	79	08
	——— S.	24	54	79	08 5
	Key Guinchos,	22	46	78	08
	Key Lobos, beacon, 20 ft.	22	[illegible]	77	33
	Las Mucaras, Diamond Point	22	11	77	14
	South edge of the Bank	22	05	76	22
	Brothers' Rocks	22	02	75	42

* See Preface.

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

Bermuda. Salt Key Bank. Little Bahama Bank.

	Lat.		Long.	
	D.	M.	D.	M.
Key San Domingo	21	42 N	75	45 W
Key Verde Island	22	02	75	10
Key Sal, (Ragged Island,)	22	12	75	42
Yuma, or Long Island, S.p.	22	50	74	50
——— N. p.	23	45	75	18
Exuma, N W. p.	23	42	76	00
THE HOLE IN THE WALL	25	51	77	09
Light on do.	25	51.5	77	10.6
N. E. point of Abaco	26	18	76	57
Elbow Reef	26	34	76	52
Man-of-War Key	26	37.5	76	57.5
Great Guano Key	26	42	77	04
Little Bahama Bank, N. p.	27	35	79	11
Memory Rock	26	57	79	06
Sand Key	26	49	79	02
Wood Key, or Cape Leno,	26	45	79	02
Great Bahama, W. p.	26	42	79	01
——— E. p.	26	40	77	48
Dog Keys, N. W. p.	24	04	79	50
Water Key	23	59	80	17
Double-headed Shot Key, (elbow,) light	23	56.4	80	27.7
Salt Key cent. beach W. side	23	41.8	80	24.3
Anguilla, E. p.	23	29	79	26
GEORGETOWN	32	22.2	64	37.6
Wreck Hill, westernmost land	32	18.5	64	50
Best latitude to run for Bermuda	32	08		

III. *East Coast of America, from Gulf of Mexico to Cape Horn.*

Texas. East Coast of Mexico.

	Lat.		Long.	
	D.	M.	D.	M.
Galveston Inlet	29	17 N	94°	45′ W
W. p. Galveston Island	29	4	95	26
Rio Brazos	29	3	95	33
Pasa del Cavallo	28	24	96	18
Aranzas Inlet	27	49	97	4
Corpus Christi	27	36	97	16
Braso de Santiago	26	6	97	12
Rio Bravo del Norte	25	56	97	12
River St. Fernando, entr.	25	22	97	32
Inlets to Laguna Madre	25	2	97	41
Bar de la Marine, entrance River St. Ander	23	45	97	58
Bar del Tordo	22	52	97	57
Mount Commandante	22	48	97	58
Bar de la Trinidad	22	39	97	57
Bar Ciega	22	34	97	58
River Tampico	22	16	98	2
Point de Xeres	21	55	97	45
Cape Rojo	21	45	97	22
Tamiagua City	21	16	97	29
River Tuspan, entrance	20	58	97	18
Point Piedras	20	46	97	12
River Cazones	20	42	97	12
Tenestequepe	20	40	97	9
Boca de Lima	20	34	97	4
River Tocoluta, entrance	20	27	97	0
Mount Gordo	20	16	97	01
River Nauta, entrance	20	13	96	47
River Palina, entrance	20	10	96	45
Point Piedras	20	00	96	35
River de Santa Nos	19	55	96	30

South Coast of the Gulf of Mexico.

	Lat.		Long.	
	D.	M.	D.	M.
Point Delgada	19	49 N	96	26 W
Point M. Andrea	19	43	96	21
Point de Bernat	19	40	96	21
River St. John Angel	19	32	96	20
Xalapa	19	32	96	50
Peak de Orizaba	19	2	97	9
Point de Sampola	19	30	96	16
River St. Carlos	19	26	96	15
River Antigua	19	20	96	14
Point Gorda	19	15	96	4
VERA CRUZ	19	12	96	9
St. John de Ulloa	19	12.5	96	8
Xamapa	19	4	95	58
River Medellin, entrance	19	6	96	4
Point Anton Lizardo	19	4	95	58
Bar de Alvarado	18	46	95	45
Tlacotalpan	18	35	95	36
Vigia	18	38	95	18
Point Roca Partida	18	43	95	11
Point Morillos	18	40	94	54
Pic de San Martin	18	30	95	10
Point Olapa	18	34	94	50
Point St. John	18	21	94	38
Barilla	18	11	94	35
Bar Guazacoalcos	18	11	94	22
River Tonato	18	18	93	59
River St. Ann	18	20	93	49
River Cupilco	18	26	93	26
Dos Bocas	18	26	93	6
River Chittepeque	18	24	93	02
River Tabasco	18	34	92	40
River St. Peter and Paul	18	38	92	32
Island Carmen, W. pt.	18	38	91	51
Point Escondido	18	58	91	15
Tavinal	19	10	90	58
Point Morros	19	45	90	43
CAMPECHE	19	49	90	33
Point Desconocida	20	46	90	26
Point Gorda	21	6	90	13
Point Piedras	21	9	90	7
Igil	21	20	89	24
St. Clara	21	22	89	2
Bocas de Silan	21	24	88	56
El Cuyo	21	30	87	43
Island Jolvas, N. p.	21	30	87	11
Island Contoy, N. p	21	36	86	52
Las Arcas Islands S. W. Id	20	13	91°	59.2
Bank Obispo centre	20	30.5	92	13
Triangles Islands N. W. Id	20	57.8	92	18.9
New Shoal	20	53	91	50
Bajo Neuva Island centre	21	50.2	91°	4.7
Island Arenas	22	7	91	25
Island Bermeja, or N. W. Shoal	22	33	91	22
Sisal Fort	21	10	90	2
Alacranes	22	32.3	89	43
N. part of Bank off this coast	23	43	88	43
N. E. do.	23	27	86	37
Isle de Mugeres, or Women's Island	21	18	86	42
Island Cawkun, S. p.	20	42	86	58
New River	20	26	87	15
River Bacales	20	5	87	34
Bay Ascension, entrance	19	26	88	3
Island Cosumel, N. p.	20	36	86	45
——— S. W. p.	20	10	87	00
Point Tanack	18	54	87	42

Digitized by Google

TABLE LIV.

Latitudes and Longitudes

		Lat.		Long.	
		D.	M.	D.	M.
	N. Triangle, N. Key	18	44 N	87	15 W
	Sandy Key, S. p.	18	22	87	18
	S. pt. Ambergris Key Isl.	17	52	88	1
	BALIZE	17	29	88	12
Honduras.	Turneff Reef, N. pt	17	39	87	41
	——— S. pt.	17	10	87	56
	English Key	17	19	88	2
	Half-Moon Key light-house	17	13	87	34
	Hat Key	17	10	87	41
	Tobaco Key Island	16	57	88	4
	Santanilla, or Swan Island	17	23	83	51
	Glover's Reef, N. p.	16	55	87	40
	——— S. p.	16	41	87	48
	Renegado Key	16	20	88	11
	Sapotilla's Keys, S. E. p.	16	10	88	14
	Rattan Island, E. p.	16	23	86	15
	——— W. p.	16	16	86	51
	Guanaja, or Bonacca Island, S. pt	16	24	86	00
	Cape Three Points	15	59	88	34
	Omoa	15	47	88	1
	Point Sal	15	53	87	48
	Triunfo de la Cruz	15	55	87	38
	Utilla, N. p.	16	6	87	2
	Truxillo	15	54	86	2
	Cape Delegado, or Honduras	16	00	86	6
	Cape Cameron	16	2	85	14
	Cape False	15	14	83	21
	Cape Gracios a Dios	15	00	83	12
	Caxones, W. p.	16	7	83	18
	——— S. E. p.	16	2	83	8
Mosquitoes.	Cayman, or Vivorilla	15	46	83	26
	Key St. Thomas	15	23	81	49
	Alagarte Alla, N. W. p.	15	9	82	27
	——— S. p.	15	1	82	25
	Seranilla, N. E. breaker	15	45	79	41
	——— W. breaker	15	41	79	58
	Sarrana, N. p.	14	29	80	16
	——— S. p.	14	15	80	23
	Guana Reefs, N. p.	14	49	80	44
	——— S. p.	13	59	80	41
	Roncador	13	39	79	46
	Musketeers, centre	13	31	80	3
	Providence Island, N. p.	13	23	81	20
	Ned Thomas's Keys, S. p.	14	12	82	21
	Bracman's Bluff	14	2	83	20
	Man-of-War Keys	13	4	82	39
	Little Corn Island	12	14	82	58
	Great Corn Island	12	9	83	3
	Bluefields, entrance	11	58	82	54
Panama.	Isle St. Andrew, middle	12	33	81	43
	E. S. E. Keys	12	24	81	28
	S. S. W. Key, or Albuquerque	12	8	81	52
	Paxoro Bovo	11	20	82	48
	River St. John, S. pt.	10	57	83	37
	Port Boco Toro	9	25	82	12
	Isle Escudo, N. p.	9	14	80	57
	River Chagre, entrance	9	19	79	59
	PORTO BELLO	9	34	79	40
	Point Manzanillo	9	39½	79	32
Darien.	Point St. Blas	9	35	79	3
	Point Moschitos	9	8	77	58
	Isle of Pines	9	1	77	50
	Cape Tiburon	8	41	77	27
	River Suniquilla, entrance	7	55	76	56
	Point Carabana	8	38	76	58

		Lat.		Long.	
		D.	M.	D.	M.
	Point Arboletes	8	55 N	76	30 W
	Island Fuerte	9	24	76	16
	Isle St. Barnard, N. W. p.	9	49	75	56
	CARTAGENA	10	26	75	38
Cartagena.	Punta de la Galera de Samba	10	47	75	30
	West entrance River Magdalen	11	5	74	56
	St. Martha	11	15	74	18
	Cape Aguja	11	20	74	16
	Bank Navio quebrador	11	26	73	15
	Hacha	11	33	72	59
	Cape La Vela	12	11	72	16
	Point Gallinas	12	25	71	44
	Monges Islands, N. p.	12	28	71	3
	Cape Chichibacoa	12	15	71	20
	Point Espada	12	4	71	13
	St. Carlos	10	57	71	44
	MARACAYBO	10	39	71	45
	Coro	11	24	69	50
Maracaybo.	Point Cardon	11	36	70	23
	Point Macolla	12	4	70	22
	Cape St. Roman	12	11	70	9
	Island Oruba, N. W. p.	12	36	70	12
	——— S. E. p.	12	24	70	1
	Point Aricula	11	56	69	56
	Point Zamuro	11	26	68	59
	Point Soldado	11	14	68	40
	Key Borracho	10	57	68	22
	Point Tucatas	10	51	68	21
	PORTO CABELLO	10	28	68	7
	Point St. John Andres	10	30	67	50
	Point Oricaro	10	34	67	18
	Point Trinchera	10	37	67	8
	LAGUIRA	10	36	67	2
	CARACCAS	10	30	67	1¼
Caraccas.	Centinella Island, or White Rock	10	50	66	15
	Cape Codera	10	36	66	12
	Curacoa Island, N. p.	12	24	69	17
	——— S. E. p.	12	2	68	49
	Little Curacoa	11	59	68	45
	Buenayre, N. p.	12	19	68	31
	——— S. p.	12	2½	68	22
	Birds' or Aves Island, western	12	00	67	46
	——— eastern	11	57	67	32
	Los Roques, W. p.	11	50	67	1
	——— S. E. p.	11	47	66	38
	Orchilla Island, middle	11	48	66	13
	Blanca Island, middle	11	51	64	41
	E. point Tortuga Island	10	55	65	18
	Seven Brothers, middle	11	47½	64	31
	Margarita, W. p.	10	59	64	30
	——— E. p.	10	59	63	52
	Island Cuagua, or Pearl Island	10	49	64	18
	Friar's Island	11	11	63	49
	Island Sola	11	20	63	40
	Testigos Island	11	23	63	13
	Morro de Unare	10	6	65	22
	New Barcelona	10	10	64	48
Cumana.	Island Borracho	10	19	64	51
	Cumana	10	28	64	16
	Pta. de Araya	10	38	64	30
	Morro Chocopata	10	42	63	54
	Escondido, or Hidden Port	10	40	63	29
	Cape Malapasqua	10	42	63	7

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat. D. M.	Long. D. M.
	Cape Three Points	10 45 N	62 46 W
	Point Galera	10 43	62 34
	Point Pena, or Salina	10 43	61 56
	Dragon's Mouth	10 43	61 51
	River Gaurapiche, entrance	10 12	62 43
	Point Redondo	9 50	61 43
	Mouth of Oronoco River	8 50	60 00
	Cape Nassau	7 32	58 40
	Essequebo River	7 2	58 26
	DEMERARA River entrance		
	Corrobano Point	6 49	58 11½
	River Berbice, entrance	6 23	57 11
	Surinam River, entrance	5 57	55 3
Surinam.	Paramaribo	5 48	55 00
	River Marouri, entrance	5 53	53 49
	CAYENNE	4 56	52 13
	Mouth of Oyapock River	4 14	51 26
	Cape Orange	4 14	51 11
	River Cassipour, entrance	3 50	51 00
	Cape North	1 49	50 6
	Northern mouth of River Amazon	1 10 N	50 00
	Southern do. do.	0 5 S	49 45
	Cape Magoany	0 12	48 29
	Point Tagioca	0 32	47 58
	Para	1 28	48 29
	Bay Maracuno	0 33	47 41
	Caite harbor	0 46	47 6
	Cape Gurapi	0 39	45 56
	Shoal off do	0 36	45 56
	E. point of Island of St. Joao	1 19.	44 50
	Vigia, fell in with by Mr. Du Sylvia, officer of the Brazilian marine, in 1824 or 1825	0 32	44 17
	Vigia of Manuel Luis, Westerly Rock	0 51	44 15
	Mondrain Itacolomi	2 9	44 25
	Mt. Alegre, (the summit,)	2 17	44 20
Maranham.	Alcantara, (west church,)	2 24	44 23
	Rock E. of Isle Medo	2 30	44 19
	City of San-Luis de Maranham, (Cathedral,)	2 31	44 16
	Fort Sant Antonio das Areias, (the flag-staff,)	2 29	44 17
	Fort San Marcos	2 28	44 16
	Isle Maranham, (white sand hills, N. part,)	2 25	44 04
	Breakers of Coroa Grande, the North one	2 10	43 58
	——— North-west one	2 13	44 4
	——— West one	2 17	44 5
	Isle St. Anne, N. E. point	2 15	43 38
	Breakers of Isle St. Anne, E. point	2 13	43 30
	Morro Alegre	2 20	43 13
	Lancoes Grande, E. point	2 26	43 00
	River Perguicas, E. point	2 41	42 27
	River Tutoya, entrance	2 41	42 12
	Pedra de Sal	2 47	41 42
	River Tapuyu, entrance	2 50	40 50
	Mt. Tapuyu, W. summit	2 58	40 51
	Mt. Ticondiba, summit	3 11	40 37
	Point de Jericacoara, the highest sand-hill	47	40 27
	Sand-hill near the shore	2 50	40 39

		Lat. D. M.	Long. D. M.
	Mount Memoca	3 18 S	40 6 W
	Roccas, (dangerous,)	3 51	33 49
	Pernambuquinho	3 2	39 37
	Morro Melancia	3 12	39 20
	Sand-hill of Parati	3 24	38 59
Brazil.	Mountains of Ciara, 1st	3 58	38 41
	——— 2d summit	3 53	38 46
	——— 3d do.	3 50	38 43
	——— 4th do.	3 46	38 49
	——— 5th do.	3 39	38 48
	Ciara, steeple in the city	3 43	38 34
	Point Macoripe	3 42	38 31
	Morro Aracati, summit	4 42	39 55
	Point Reteiro Grande	4 36	37 33
	Reteiro Pequeno, remarkable sand-hill	4 48	37 19
	Morro Tibao	4 49	37 18
	Point de Mel	4 55	36 59
	Point du Tubarro	5 2	36 28
	(Breaker) das Urcas	4 52	36 19
	——— de la Lavandela	4 55	36 20
	Pt. Calcanhar, summit	5 8	35 31
	Point Petetinga, low	5 22	35 20
	CAPE ST. ROQUE	5 28	35 17
	Fort of Rio Grande	5 45	35 15
	Point Negra, mountain	5 53	35 12
	Point Pipa, sand mount	6 13	35 4
	Bahia Fermosa, S. point	6 23	35 00
	Bahia da Traicao, N. pt.	6 41	34 57
	Church of St. Theresa	6 57	34 53
	Fort Cabedello	6 58	34 50
	Paranahyba de Norte	7 6	34 53
Brazil.	Cape Blanco, steep part	7 8	34 48
	Point de Guya	7 26	34 47
	Point das Pedras	7 35	34 48
	Village of Pilar	7 36	34 48
	Fort, entrance of Rio Ay	7 47	34 51
	Nossa Senora Farinha	7 57	34 51
	Olindo, west tower	8 1	34 51
	Tower de Recife, Pernambuco	8 4	34 53
	Nossa Senhora de Rosario	8 9	34 56
	CAPE ST. AUGUSTIN	8 21	34 57
	River Ipojuca, entrance	8 23	34 58
	Mount Sellada, S. peak	8 25	35 11
	Islands of St. Alexio	8 36	35 1
	Fort de Tamandaré	8 43	35 5
	San Bento	9 5	35 17
	Village of Quinta	9 16	35 22
	La Forquilha, (hill,)	9 10	35 48
	Frenchmen's Port	9 40	35 41
	Village at the point of River Alagoas	9 40	35 47
	Morro Sant Antonio	9 22	35 35
	River San Francisco	10 29	36 23
	Tabayana Mountain, summit	10 47	37 23
	Rio Vasa Barris	11 11	37 17
	Rio Real, S. point	11 28	37 20
Brazil.	Torre de Garcia de Avila	12 32	38 1
	River Jacuipe	12 42	38 7
	Rock of Itapuan	12 58	38 22
	Itapuanzinko, the point	13 1	38 28
	ST. ANTONIO, N. W. tower	13 0	38 32
	Point Caxo Pregos, Isle Itaporica	13 8	38 46
	Point Aratuba, do.	13 5	38 44

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat. D.	Lat. M.	Long. D.	Long. M.
Brazil.	Point Iaburu, Isle Itaporica	12	57 S	38	36 W
Brazil.	Mount Conceicao, do.	13	3	38	41
Brazil.	Morro Sant Amarro, do.	13	1	38	45
Brazil.	Morro de San Paulo	13	22	38	54
Brazil.	Isle Boypeda	13	38	38	57
Brazil.	Isle Quiepi	13	51	38	57
Brazil.	Point of Muta	13	53	38	57
Brazil.	Villa of Contas	14	18	39	00
Brazil.	Os Itheos, the largest rock	14	47	38	59
Brazil.	Villa de San George dos Itheos	14	49	39	00
Brazil.	Rio Cachoeira, S. point	14	49	38	59
Brazil.	Villa of Unha	14	59	38	58
Brazil.	Morro de Commandatuba, S. E. summit	15	22	39	8
Brazil.	Village of Commandatuba	15	25	38	56
Brazil.	Village of Belmont	15	51	38	54
Brazil.	Santa Cruz, steeple	16	19	39	2
Brazil.	Porto Seguro, steeple of the Cathedral	16	27	39	3
Brazil.	Isolated Mount	16	52	39	31
Brazil.	Mount Pascal, summit	16	54	39	25
Brazil.	Mount Joao de Siam	17	0	39	37
Brazil.	River Cramimuam	16	51	39	9
Brazil.	Columbiana	17	6	39	12
Brazil.	Villa Prado, fort	17	21	39	12
Brazil.	Abrolhos Islands, (the largest island,)	17	58	38	42
Brazil.	Rio de San Mattheo	18	37	39	45
Brazil.	Rio Doce, entrance	19	37	39	51
Brazil.	Serra dos Reis Magos, the S. summit	19	50	40	22
Brazil.	Morro Almeyda	19	57	40	20
Brazil.	Mestre Alvaro, summit	20	9	40	22
Brazil.	Cape Zubarro	20	16	40	17
Brazil.	"Piton," at the N. of the city of Victoria	20	18	40	23
Brazil.	Nossa Senhora da Penha, church	20	20	40	20
Brazil.	Mount Morena	20	19	40	19
Brazil.	Pacotes Rocks	20	21	40	17
Brazil.	Point Jicu	20	26	40	22
Brazil.	Isles Rasas	20	43	40	25
Brazil.	Isle Calvada	20	44	40	27
Brazil.	Guarapari	20	44	40	33
Brazil.	Morro Bo, (isolated mountain,)	20	48	40	41
Brazil.	Morro de Benevento	20	55	40	49
Brazil.	Serra de Guarapari	20	50	41	8
Brazil.	Mt. de Campos, S. summit	21	23	41	28
Brazil.	Mountains of Furado, highest	21	50	41	43
Brazil.	CAPE ST. THOMAS	22	3	41	00
Brazil.	Isle St. Anne, the largest	22	25	41	46
Brazil.	Pic do Frade de Macahe	22	12	42	9
Brazil.	Morro San Joao, summit	22	32	42	6
Brazil.	Cape Buzios, S. point	22	46	41	56
Brazil.	Isles Ancora, easternmost	22	46	41	51
Brazil.	CAPE FRIO, S. point	23	1	41	59
Brazil.	Cape Negro	22	57	42	35
Brazil.	Isles Maricas, southernmost	23	1	42	51
Brazil.	Redondo	23	4	43	9
Brazil.	RIO JANEIRO, (Sugar Loaf,)	22	56	43	9
Brazil.	La Gabia	22	59	43	23
Brazil.	Isle Georgi Grego	23	15	44	19
Brazil.	O. Pakagaio, top of Isle Grande	23	11	44	21
Brazil.	Ilha Grande, Pt. Acaya	23	15 S	44	29 W
Brazil.	Point Ioatinya	23	18	44	39
Brazil.	Pic de Parati, summit	23	19	44	54
Brazil.	Isle Couves, largest	23	26	44	58
Brazil.	Isle Victoria	23	48	45	14
Brazil.	Isle Buzios, S. E.	23	44	45	6
Brazil.	Isles dos Porcos, S. sand-hill	23	34	45	10
Brazil.	Isle St. Sebastian, highest mountain	23	48	45	22
Brazil.	—— Pt. Pirasonungo	23	58	45	20
Brazil.	Mouton de Trigo	23	51	45	52
Brazil.	Lage de Santos	24	18	46	17
Brazil.	Point Grossa	23	59	46	24
Brazil.	—— Taypu	24	1	46	30
Brazil.	Isle Queimada Grande	24	28	46	47
Brazil.	Isle Queimada Pequena	24	21	46	54
Brazil.	Poin Jurea	24	33	47	19
Brazil.	Mount Cardoz	24	59	48	12
Brazil.	Isle Bon Abrigo	25	7	47	58
Brazil.	Rocher Castello	25	16	48	3
Brazil.	Rocher Figo	25	22	48	10
Brazil.	Isle de Mel, S. top	25	33	48	26
Brazil.	Roc Coral	25	46	48	30
Brazil.	Roc Itascolomi	25	50	48	33
Brazil.	Point Joao Diaz	26	7	48	40
Brazil.	Isles Tamboretes	26	21	48	39
Brazil.	Isles Remedios	26	29	48	42
Brazil.	Point Itapacoroya	26	47	48	44
Brazil.	Isle Arvooredo, top	27	17	48	29
Brazil.	Isle St. Catharine, E. pt.	27	26	48	29
Brazil.	—— Pt. Rapa	27	23	48	32
Brazil.	—— Steeple of Nossa Senhora do Desterro	27	36	48	40
Brazil.	Morro de Sta Marta	28	39	48	51
Brazil.	Porto St. Pedro	32	07	52	9
River Plate.	Cape St. Mary	34	39	54	10
River Plate.	Island Lobos	35	01	54	54
River Plate.	Maldonado harbor	34	53	55	00
River Plate.	Point Piedras	35	27	57	5
River Plate.	MONTE VIDEO, Rat Is.	34	53	56	13
River Plate.	BUENOS AYRES	34	36	58	22
River Plate.	Cape St. Antonio	36	19	56	46
	Cape Lobos	36	55	56	47
	Cape Corientes	38	06	57	27
	Point de Neuva	42	53	64	8
	St. Helena	44	31	65	22
	St. George's Bay, Cape Cordova	45	46	67	21
	Cape Blanco	47	12	65	43
	Point Desire, ruins	47	45	65	54
	Port St Julian, Cape Curioso	49	11	67	37
	St. Cruz harbor	50	09	68	19
	Cape Fairweather	51	32	68	55
	Cape Virgin, northern point of entrance to Magellan Straits	52	20	68	21
Terra del Fuego.	Cape Espirito Santo, (extreme point of do.)	52	38	68	35
Terra del Fuego.	Terra del Fuego; Cape Penas	53	51	67	33
Terra del Fuego.	—— Cape St. Diego	54	41	65	7
Terra del Fuego.	Staten Island, Cape St. John, easternmost land near Cape Horn	54	43	63	43
Terra del Fuego.	—— Cape St. Bartholomew	54	54	64	45

Digitized by Google

TABLE LIV

Latitudes and Longitudes.

		Lat. D. M.	Long. D. M.
	Staten Island; Cape del Medio, entrance to Le Maire's Straits........	54 48 S	64 45 W
Terra del Fuego.	New Island, E. part......	55 17	66 26
	Evout's Island	55 33	66 45
	Barnevelt Island, E. part.	55 48	66 45
	CAPE HORN, S. part of Hermit's Island........	55 59	67 16

IV. *West Coast of America, from Cape Horn to Icy Cape.*

		Lat.	Long.
	CAPE HORN...........	55 59 S	67 16 W
	Isl. Diego Ramires, S. part	56 27	68 36
	——— N.rock	56 22	68 37
	Island St. Ildefonso, S. p..	55 53.5	69 17
	Terra del Fuego		
	——— False Cape Horn.	55 43	68 6
	——— York Minster, S. E. extremity...........	55 24	70 2
	——— Cape Gloucester.	54 30	73 02
	——— Cape Pillars, N. entr. Magellan's Straits.	52 43	74 38
	Evangelist Island, W. ent. Magellan's Straits	52 24	75 3
	Cape Victory	52 16	74 55
	West Cliff Cape..........	50 36	75 32
	Cape Three Points........	50 2	75 21
	Mount Corso, S. pt.......	49 50	75 32
	Isl. Campana, N. point...	47 59	75 23
	Cape Tres Montes........	46 59	75 28
	Cape Taytao.............	45 53	75 8
	Island Huafo, N. W. part.	43 35	74 49
	Point Quilan.............	42 52	73 33
	Point St. Carlos.........	41 51	73 52
	Point Quedal	41 3	74 1
	Point de la Galera.......	40 2	73 47
	VALDIVIA, near Fort Coral	39 53	73 29
	Point Tirua..............	38 23	73 33
	Isl. de la Mocha, N.W. part	38 20	74 1
	St. Maria Islands, N. p. ..	36 58	73 35
	——— S. p. ..	37 5	73 34
Coast of Chili.	CONCEPTION, city	36 49	73 5
	Talcahuano, Fort	36 42	73 10
	Topocalmo Pt.	34 11	72 5
	VALPARAISO, Fort ...	33 2	71 41
	Point Ballena	31 57	71 36
	Coquimbo	29 54	71 19
	Huasco	28 27	71 19
	Copiapo	27 20	71 2
	Sugar Loaf Islet, summit.	26 9	70 47
	Island St. Felix, Eastern .	26 20	79 47
	——— Western	26 16	80 3
	Pt. dos Reyes	24 34	70 40
	Morro Moreno, summit ..	23 28	70 38
	Mexilones Hill, summit ..	23 6	70 35
	Point Tames............	22 45	70 23
	Pt. Francisco	21 56	70 15
	Pavellon de Pica	20 58	70 14
	Point Piedras	20 9	70 14
	Pisagua, Point Pichalo ...	19 37	70 19
	Arica, Head	18 28	70 24
	Point de Coles	17 42	71 26
	Ilo, rivulet mouth	17 37	71 24
	Point Cornejo...........	16 52	72 21

		Lat. D. M.	Long. D. M.
	Point Pescadores	16 24 S	73 20 W
	Atico cove..............	16 13	73 45
	St. Juan, needle hummock	15 21	75 13
	Mount Carreta..........	14 10	76 20
	Pisco, middle	13 43	76 16.5
	Point Frayle	13 1	76 35
	Point Chilca	12 31	76 53
	Isl. St. Lorenzo, N. pt. ...	12 4	77 19
	LIMA	12 3	77 6
	CALLAO Bay, flagstaff..	12 4	77 13
Perú.	Island Pescador, summit of largest, W. pt.	11 47	77 20
	Los Hormigas Rocks.....	11 58	77 50
	Island Pelada	11 27	77 53
	Island Don Martin	11 2	77 43
	Point Santander.........	10 38	77 56
	Rock seen in 1792.......	10 48	78 48
	Ferrol Bay, ent. (Blanco Is.)	9 6	78 39
	Truxillo, church	8 8	79 4
	Malabrigo, (port,)	7 43	79 28
	Island Lobos de Amera, fishing-cove...........	6 57	80 44
	Island Lobos de Tierre...	6 27	80 53
	Eten	6 57	79 54
	Point de Ajugo.........	5 55	81 10
	Point Payta............	5 5	81 10
	Cape Blanco...........	4 17	81 16
	Point Malpelo..........	3 31	80 30
	GUAYAQUIL, city.....	2 13	79 53
	Island Puna, S. W. p.....	3 4	80 8
	Point St. Helena	2 10	80 48
	Island Pelado	1 56	80 36
	Point del Callo.........	1 23	80 34
	Island de la Plata, W. p...	1 18	80 57
Quito.	Cape St. Lorenzo........	1 4	80 43
	Manta	0 57	80 32
	Cape Pasado	0 27	80 20
	Quito	0 18	78 18
	Arbol	0 15 N	79 48
	Cape St. Francisco	0 39	80 6
	Point de la Galera.......	0 48	79 51
	River Esmeraldas, entrance	0 58	79 39
	Point Mangles	1 33	79 7
	Island Tumaco.........	1 47	78 50
	Point Guascama	2 40	78 32
	Island Gorgona, middle ..	2 59	78 26
	River Cajambrie, entrance	3 19	77 15
	Island de Malpelo	3 55	81 36
	Island de Palmas	3 57	77 7
	Point Chirembira........	4 13	77 26
	Cape Corientes.........	5 34	77 26
	Limones...............	6 3	77 23
	Point St. Francisco Solano	6 49	78 00
	Point Garachine	8 4	78 30
	PANAMA Ft. N. E. Bastion	8 57	79 31
	Point Mala	7 24	80 2
Panama.	Puercos Point..........	7 13	80 27
	Island Quibo, N. p.	7 31	81 46
	Los Ladrones	7 52	82 37
	Point Burica	8 0	83 0
	Gulfe Dulce, W. p.......	8 23	83 29
	Isl. Cano, ent. Engl. Harbor	8 44	84 4
	Cape Herradura........	9 37	84 37
	Cape Blanco	9 32	85 2
	Nicoya, wat'g pl. on E. side	9 38.5	84 36
	Morro Hermoso	10 8	85 30
	Point Culebra, Gorda Pt.	10 32	85 43
	St. John's Harbor	11 15	85 50

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

Region	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
	Point Desolado	12	22 N	86	58 W
	Leon	12	26	86	49
	Realejo. entr.	12	28	87	8
	Aseradores	12	35	87	20
	Point Cosignina	12	53	87	37
	Point Candadillo	13	7	87	57
	Sacatecoluca	13	26	88	32
	Point Remedios	13	35	89	43
	Point Guatimala	13	54	90	53
	Puerto Ventosa	16	8	95	0
	Agualco	16	2	96	52
	ACAPULCO	16	55	99	48
	Cape Corientes	20	26	105	35
	St. Blas	21	30	105	13
	Tres Marias	21	28	106	29
	St. Joseph	23	4	109	38
	Cape St. Lucas	22	52	109	52
	Morro Hermosa	27	46	114	41
	Redondo Island	29	49	115	10
	Port San Quentin	30	22	115	57
	Bay Todos Santos	31	49	116	43
	Port Diego	32	41	117	11
	Point Conception	34	27	120	25
	Monterey	36	37	121	51
	Port St. Francisco	37	48	122	21
	Cape Mendocino	40	28	124	20
North-west Coast of America.	Port Trinidad	41	3	124	7
	Cape Blanco, or Orford	42	53	124	37
	Cape Gregory	43	26	124	21
	Cape Foulweather	44	52	124	5
	Cape Rond	45	43	123	48
	Cape Disappointment	46	16	124	1
	Cape Flattery	48	7	124	43
	Breakers' Point	49	24	126	30
	NOOTKA, N. pt.	49	36	126	35
	Woody Point	50	6	127	43
	Bay St. Louis	50	34	128	14
	Isles de Sartine, or Scott	50	56	128	50
	Cape Scott	50	48	128	20
	Cape Caution	51	12	127	52
	Cape Hector, or James	51	57	131	7
	Bay de la Touche	52	42	132	10
	Cape Henry	52	53	132	27
	Bay de Clouard	53	52	133	21
	Point North	54	20	133	15
	Cape St. Bartolomo	55	12	133	38
	Cape Ommaney	56	12	134	35
	Port Guibert	56	38	135	00
	Port Neckar	56	43	135	4
	Cape Engano, or Edgecomb	57	2	135	50
	Port Gaudaloupe	57	10	135	43
	Port de los Remedios	57	24	135	43
	Cape Cross	57	57	136	24
	Port des Francais	58	37	137	20
	Cape Fairweather	58	55	137	52
	Behring's Bay	59	18	139	00
	Point de la Boussole	59	50	140	55
	Mount St. Elias	60	23	140	45
	Cape Hinchinbroke	60	15	146	16
	Cape Elizabeth	59	9	151	28
	Barren Isles	59	00	151	46
	Point Banks	58	41	152	6
	Cape Douglass	58	56	152	50
	Cape Whitsunday	58	15	151	46
	Cape Grenville	57	33	152	00
	Trinity Islands	56	36	153	40
	Foggy Island	56	10	156	45
North-west Coast of America.	Halibut Head Island	54	27 N	162	30 W
	Ounalashka Island, N. p.	53	55	166	12
	Bristol River, entrance	58	12	157	33
	Round Island	58	29	159	53
	Cape Newnham	58	34	161	55
	Shoalness	60	00	161	52
	Cape Stephens	63	33	162	17
	Cape Denbigh	64	17	161	53
	Cape Rodney	64	34	166	37
	Cape Prince of Wales	65	45	168	17
	Cape Mulgrave	67	45	165	12
	Cape Lisburne	69	5	165	22
	ICY CAPE	70	29	161	42

V. *From the River St. Croix to Cape Canso.*

Region	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
	Entrance St. Croix River	45	00 N	67	2 W
	Macgone's Isl. (entrance of St. John's River)	45	13	66	5
	Cape Spencer	45	12	65	55
	Cape Chignecto	45	18	64	58
	Haute Island	45	15	65	0
	Annapolis Gut	44	42	65	45
	Breyer's Island light	44	16	66	22
	St. Mary's Cape	44	6	66	11
	Cape Fourchu	43	50	66	7
	Seal Island light	43	24	65	58.5
Nova Scotia.	CAPE SABLE	43	24	65	36
	Sable Island, E. pt.	43	59	59	47
	——— W. pt.	43	57	60	14
	Cape Roseway, Shelburne lights	43	38.5	65	15.5
	LIVERPOOL, Coffin's Island lights	44	3	64	36
	Lunenburg, Cross Island lights	44	20	64	7
	Sambro light-house	44	26.6	63	33.3
	HALIFAX Obs. D. Yard	44	39.4	63	35
	Sheet Harbor, entrance	44	52	62	29
	Sherbroke	45	8.5	62	0
	White-Head Island	45	12	61	10
	Torbay, Berry Head	45	11	61	20
	CAPE CANSO, Cranberry Island light	45	19.5	60	55.3

VI. *The Gulf of St. Lawrence.*

Region	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
	Chedabucto Bay	45	29 N	61	00 W
	Gut of Canso, S. entrance	45	30	61	13
	Cape Hinchinbroke	45	34	60	42
	Cape Portland	45	49	60	5
	LOUISBURGH	45	53.5	60	00
	CAPE BRETON	45	57	59	48.5
Cape Breton.	Scatari Island, N. E. pt.	46	2	59	41
	Flint Island	46	12	59	47
	Spanish Bay, Sidney light	46	18	60	9
	Port Dauphin	46	24	60	31
	Cape Egmont	46	53	60	22
	Cape North	47	2	60	24
	Chetican Harbor, entrance	46	40	60	59
	Seal Island	46	23	61	15
	Cape Mabou	46	12	61	26
	Port Hood, entrance	46	00	61	34
	Just au Corps Island	46	00	61	37

Digitized by Google

TABLE LIV

Latitudes and Longitudes

	Lat. D. M.	Long. D. M.
GUT OF CANSO, N. entrance	45 42 N	61 29 W
Cape St. George, N. end	45 53	61 52
Pictou Island, E. pt.	45 49	62 33
Pictou light	45 41.5	62 40
Cape Tormentin, S. E. pt.	46 05	63 50
Richibucto Harbor, entr.	46 43	64 50
Prince Edward's Isl.		
Cape North	47 03	64 01
Cape West	46 41	64 23
Egmont or Halifax Bay, Red Head	46 26	64 08
Hillsborough Bay, St. Peter's Isl.	46 07	63 14
Bear Cape	46 00	62 29
Cape East	46 28	61 59
Richmond Bay	46 34	63 44
Cape Esquiminac	47 04	64 46
Miscou Island, (entrance of Chaleur Bay)	48 01	64 31
Cape Despair	48 25	64 21
Bonaventure Island	48 30	64 10
Flat Island	48 38	64 11
Cape Gaspé	48 45	64 12
Cape Rosier	48 51.7	64 14.8
Magdalen River	49 15	65 22
Cape Chatte	49 06	66 48
Bic Island, Riv. St. Law. E. pt.	48 25	68 53
Anticosta Island, E. pt.	49 05	61 45
——— West pt.	49 52	64 35
——— S. W. pt.	49 24	63 36
——— S. point.	49 04	62 18.5
——— N. point	49 58	64 12
Magdalen Isles.		
Deadman's Island	47 16	62 15
Entry Island	47 17	61 42
Amherst Isl. S. W. pt.	47 13	62 04
Magdalen Isles, E. pt.	47 37.6	61 26
Byron Island, E. pt.	47 48	61 25
Bird Island	47 51	61 10
St. Paul's Island	47 14	60 11

VII. *Newfoundland.*

Newfoundland.	Lat. D. M.	Long. D. M.
Limits of the Great Bank of Newfoundland, N. point	50 15 N	51 10 W
——— S. point	42 56	50 00
Outer Bank	47 00	45 00
Cape Norman	51 38.1	55 56.3
Green Island	51 24	56 37
Point Ferrole	51 02.4	57 05.6
Point Riche	50 42	57 27
Ingornechoix Bay, Port Saunders	50 39	57 21
Bay of St. Paul's	49 50	57 51
Bon Bay	49 33	58 00
Cape St. Gregory	49 22	58 16
South Head	49 06	58 21
Red Island	48 34	59 16
Cape St. George	48 28	59 15
Cape Anguile	47 54	59 27
Cape Ray	47 36.9	59 20.2
Connoire Bay	47 40	58 00
Burgeo's Isles	47 33 N	57 43 W
Rainea Islands	47 32	57 25
Penguin's Islands	47 22	57 01
Fortune Head	47 05	55 51
Brunet Island, W. H.	47 16	56 00
Great Miguelon, Cape M.	47 08	56 26
Langley's Island, Cape L.	46 48	56 27
St. Peter's Island, S. E. pt.	46 45	56 10
Point May	46 54	56 04
Cape Chapeau Rouge	46 53	55 27
Mortier Rocks	47 02	54 57
Red Island, S. pt.	47 23	54 15
Virgin Rocks	47 10	54 11
Point Breem	46 59	54 16
Cape St. Mary	46 50	54 13
Cape Pine	46 38	53 35
CAPE RACE	46 39.4	53 04.6
Cape Race, (Virgin) Rocks	46 26.3	50 55
Cape Ballard	46 47	52 59
Cape Broyle	47 05	52 52
Bay of Bull	47 18	52 47
Cape Spear	47 30.5	52 39
St. John's Harbor	47 34	52 43
Cape St. Francis	47 48	52 51
Breakheart Point	48 09	52 59
Trinity Harbor	48 22	53 24
Cape Bonavista	48 42	53 08
Funk Island	49 45	53 12
Cape Freels	49 18	53 30
Wadham Islands	49 34	53 55
Gander Bay	49 28	54 26
Fago Islands, cape	49 41	54 00
Snap Rock	49 55	53 44
Tuolinguet Islands	49 42	54 44
Cape St. John, N. Bill	50 00	55 31
Horse Islands, E. pt	50 13	55 43
White Bay, entrance	50 13	56 21
Hooping Harbor	50 37	56 14
Belle Isle, *southern*	50 49	55 29
Groais Island, N. pt.	50 58	55 35
Hare Bay, entrance	51 16	55 41
St. Anthony's Cape	51 23	55 31
St. Lunaire Bay	51 29	55 29
Cape Bauld	51 39.7	55 27.4
Belle Isle, *northern*	52 01.3	55 19.1
Oroque Harbor	51 03	55 50

VIII. *From Quebec to Hudson's Bay*

Canada.	Lat. D. M.	Long. D. M.
QUEBEC	46 49.1	71 16 W
Coudras Isl. N. W. part	47 24.6	70 28
Bay of Rocks	47 57	69 50
Green Island light	48 03.4	69 28.2
Point Mille Vache	48 34	69 11
Bersimis Point, S. E. pt.	48 54.1	68 41.6
Manicougan Point	49 06.2	68 15
Cape Nicholas	49 15.9	67 53.2
Cape Montpelles light-h.	49 19.7	67 25
Egg Island	49 38.3	67 13
Seven Islands Bay, Store	50 13	66 25
Point Moisic	50 11.4	66 07.7
Lobster Bay	49 49.5	67 06
Point Manitou	50 17.7	65 17.1
St. John's River	50 18	64 23

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

Labrador.

	Lat.		Long.	
	D.	M.	D.	M.
Mingan Island	50	12.9	64	10.5
Esquimaux Island	50	13	63	41
Clear-water Point, S.W. ex.	50	12.6	63	28
Appeetetet Bay	50	16.7	63	01
Mount Joli, Natashquan Pt.	50	06	61	46
Cape Whittle	50	10.7	60	09.8
Boat Islands	50	17	59	46
St. Mary's Islands, S. pt.	50	13	59	45
Hare Harbor	50	36.5	59	20.1
Great Mecatina P., S. E. p.	50	44	58	53
Mistanoque Island	51	15.8	58	15.1
Grand Point	51	25	57	14
Forteau Bay Point	51	25.6	56	59.4
Red Cliffs	51	33	56	47
Red Bay	51	44	56	28.4
York Point	51	58	55	55.9
Cape Charles	52	14	55	22
Battle Island, S. E. pt.	52	16	55	33
Cape St. Lewis	52	21	55	41
Cape Harrison	54	54	58	05
Enchanted Cape	56	40	60	55
Cardinal's Island	58	50	63	00
Button Islands	60	45	64	53

IX. *Hudson's Bay and Straits, and Davis's Straits.*

Hudson's and Davis's Bay and Straits.

	Lat.		Long.	
	D.	M.	D.	M.
Cape Resolution	61	29 N	64	30 W
Saddle-Back Island	62	11	67	43
Upper Savage Island, E. pt.	62	32	70	0
North Bluff	62	34	70	25
Capes Charles	62	46	74	15
Cape Dorset	64	32	78	0
Cape Pembroke	63	37	82	20
Cape Walsingham	62	30	77	48
Cape Digges, W. ex.	62	37	78	35
Salisbury Islands, E. pt.	63	27	76	40
Mansfield Island, N. part	62	23	79	50
——— S. part	61	31	80	25
Cape Southampton	62	6	84	50
North Sleepers	60	3	80	50
West Sleepers	60	8	81	36
Portland Point	58	48	79	2
Baker's Dozen	58	5	79	30
Belcher's N. point	56	20	80	15
James's Bay,				
——— Cape Henrietta	55	10	82	30
——— Cape Jones	54	50	78	54
——— N. Bear Isle	54	24	80	50
——— North Cub	54	20	80	48
——— The Twins	53	12	80	35
——— Albany Fort	52	14	82	00
Moose Fort	51	16	80	56
Charlton Island	52	3	79	55
York Fort	57	2	92	32
Cape Churchill	58	48	93	12
Prince of Wales's Fort	58	48	94	14
Marble Island	62	33	91	6
Cape Dobbes	65	00	86	42
Cape Walsingham	66	0	60	28
Dyer's Cape	66	42	60	28
Sanderson's Hope	72	42	56	10
Cape Bedford	66	55	68	30
Waygate Island	70	27	54	40

X. *Greenland.*

Greenland.

	Lat.		Long.	
	D.	M.	D.	M.
Musquito Cove	64	55 N	52	57 W
Gothaah, ent. of River Bal.	64	10	51	47
Bear Sound	63	20	49	10
Maab	62	5	48	27
Cape Farewell	59	49	43	54
Whale's Island	62	30	43	15
Herjoisness	65	3	29	50
Bontokoe Island, S. E. pt.	73	29	20	40
Gael Hamkes Bay	75	00	6	51
John Mayen's I., N.E. Cape	71	10	7	26

XI. *Iceland.*

Iceland.

	Lat.		Long.	
	D.	M.	D.	M.
Cape Reikianess	63	48 N	22	42 W
Bessested	64	6	21	54
Mount Suaesell	64	52	23	54
Patrixfiord	65	36	24	10
Straumness	65	40	24	29
North Cape	66	28	22	26
Hola	65	44	19	44
Grim's Island, N. pt.	66	34	18	04
Rikefiord	66	30	17	35
Longnose, Cape	66	23	14	31
Enchuisen Island	64	20	14	15
Wreeland do.	63	55	18	19
Cape Hecla, Mt.	63	58	19	41
Westman's Island, S. pt.	63	20	20	23

XII. *Spitzbergen.*

Spitzbergen.

	Lat.		Long.	
	D.	M.	D.	M.
South Cape	76	32 N	17	23 E
Fair Foreland	78	53	10	35
Amsterdam Island, (Hackluyt's Head,)	79	46	10	57
Smeerenburg Harbor	79	44	11	11
Verlegen Hook	80	2	16	37
Hope Island, W. pt.	76	20	20	50
Bear or Cherry Island	74	30	20	00

XIII. *English Coast, from London to St. Mary's Light, (Scilly.)*

South Coast of England.

	Lat.		Long.	
	D.	M.	D	M.
LONDON	51	31 N	0	6 W
GREENWICH Observ.	51	29	0	0
Woolwich	51	30	0	4 E
Purfleet	51	30	0	19
Gravesend	51	28	0	22
Rochester	51	23	0	32
Sheerness	51	27	0	44
Nore light	51	29	0	48
North Foreland light	51	22	1	27
South Foreland lights	51	8	1	22
Deal Castle	51	13	1	24
DOVER	51	8	1	19
Dungeness	50	55	0	58
Hastings lights	50	52	0	36

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

Region	Place	Lat. D. M.	Long. D. M.
South Coast of England.	Beachy Head light	50 44 N	0 13 E
	Brighton light	50 50	0 8 W
	Shoreham lights	50 50	0 15
	Arundel	50 53	0 35
	Selsey Bill	50 43	0 48
	Owers light	50 41	0 40
	PORTSMOUTH, town	50 47	1 6
Isle of Wight.	Isle of Wight,		
	—— Cowes, Castle	50 46	1 18
	—— Bembridge Ledge or Point, Ft. light	50 42	1 2
	—— Dunnose	50 37	1 11
	—— St. Cath'ne's Pt. lt.	50 35	1 18
	—— Needle's lights	50 40	1 34
	Hurst light	50 42	1 33
	Poole light	50 41	1 56
	St. Alban's Head	50 35	2 3
	Weymouth light	50 37	2 26
	Portland lights	50 31	2 27
	Exmouth Bar	50 38	3 21
	Torbay, Berry Head	50 24	3 28
	Dartmouth	5c 21	3 33
	Start Point	50 13	3 38
	Praul's do.	50 13	3 42
	Bolt Head	50 13	3 48
	Eddystone light	50 11	4 16
	Hand Deeps	50 13	4 20
	Ram Head	50 19	4 13
	PLYMOUTH, Mt.	50 22	4 10
	Fowey	50 20	4 38
	Deadman's Point	50 13	4 47
	Falmouth light	50 8	5 1
	Manacles Rocks	50 2	5 3
	Black Head	50 00	5 07
	LIZARD Point	49 58	5 12
	Mount's Bay	50 8	5 30
	Penzance light	50 7	5 31
	Rundle's Stone, beac.	50 1	5 40
	Wolf Rock	49 57	5 48
	Land's End	50 4	5 42
	St. Agnes' light, (Scilly,)	49 54	6 21
	St. Mary's	49 55	6 19
	St. Martin's	49 58	6 15

XIV. *French Coast from Calais to Ushant.*

Region	Place	Lat. D. M.	Long. D. M.
North Coast of France.	CALAIS	50 58 N	1 51 E
	Cape Griz Nez	50 52	1 35
	Ambleteuse	50 48	1 36
	BOULOGNE	50 44	1 37
	Etaples Bay, Lornet light	50 33	1 39
	Montreul	50 28	1 45
	La Rochelle	50 19	1 40
	Abbeville	50 7	1 50
	Grotoy	50 13	1 38
	St. Vallery, River Somme	50 11	1 38
	Dieppe light	49 56	1 5
	St. Valley, River Caux	49 52	0 43
	Fecamp light	49 46	0 22
	Cape de Caux	49 41	0 11
	Cape de le Heve lights	49 31	0 4
	HAVRE DE GRACE	49 29	0 6
	PARIS Observatory	48 50	2 20
	Mouth of Seine	49 27	0 3
	Harfleur	49 30	0 11
North Coast of France.	Honfleur lights	49 25 N	0 14 E
	Caen	49 11	0 21 W
	Bayeux	49 16	0 43
	Carentan	49 18	1 15
	St. Marcouf Island light	49 30	1 9
	Cape Barfleur light	49 42	1 16
	CHERBOURGH	49 38	1 37
	Pelee Island	49 40	1 36
	Cape la Hogue	49 44	1 56
	Alderney Island, N. point	49 46	2 12
	Caskets lights	49 43	2 23
	Guernsey, Pier Hd. light	49 27	2 33
	Sark Island, N. point	49 26	2 23
	Jersey Island,		
	—— Cape Grosness	49 15	2 16
	—— St. Aubin	49 13	2 11
	—— St. Clement's Point	49 9	2 00
	Isle de Chausey lights	48 52	1 49
	Coutances	49 3	1 27
	Granville, Mole Hd. light	48 50	1 36
	Avranches	48 41	1 22
	Mount St. Michael	48 38	1 31
	Pontorson	48 33	1 32
	St. Malo, New Mole light	48 39	2 2
	Cape Frehel light	48 41	2 19
	St. Brieux, Cath.	48 31	2 46
	Brehat Island, Centre	48 51	3 00
	Tregueir	48 47	3 15
	Morlaix light on T. la Lande	48 38	3 53
	St. Pol de Leon	48 41	4 00
	Isle de Bas light	48 45	4 1
	Roche Blanche	49 1	3 58
	St. Anthony's lights	48 40	4 29
	USHANT, N.E. point, light	48 29	5 3

XV. *From the North Foreland to Duncansby Head.*

Region	Place	Lat. D. M.	Long. D. M.
East Coast of England.	North Foreland	51 23 N	1 27 E
	Kentish Knock, Ft. light	51 40	1 39
	Long Sand Head	51 45	1 38
	Galloper, N. point	51 52	2 5
	——— S.W. point Ft. lt.	51 45	1 56
	Shipwash, N. point, Ft. lt.	52 02	1 38
	——— S. point	51 53	1 33
	Gaberd, outer	51 58	1 59
	Orfordness lights	52 5	1 34
	Aldboro' Steeple	52 9	1 36
	Southwold	52 20	1 41
	Loestoff lights	52 29	1 46
	Yarmouth	52 37	1 44
	Winterton Ness lights	52 43	1 41
	Smith's Knowl, S. pt.	52 48	2 14
	Hasborough Sand, S. p.	52 51	1 48
	——— N. p.	53 2	1 35
	Sherringham Shoals	53 3	1 20
	Hasborough lights	52 49	1 32
	Cromer lights	52 56	1 19
	Lemon and Ower, N. p.	53 14	1 58
	——— S. p.	53 8	2 00
	Cromer light	52 56	1 19
	Dudgeon light	53 15	0 56
	Outer Dowsing	53 33	1 14
	Inner Dowsing	53 18	0 33
	Lynn Knock	53 3	0 29

Digitized by Google

TABLE LIV.

Latitudes and Longitudes

	Lat. D. M.	Long. D. M.
Spurn lights	53 35 N	0 7 E
Flamborough Head light	54 7	0 5
Filey Brig	54 15	0 1 W
Scarborough light	54 17	0 23
Robin Hood's Bay	54 27	0 20
Whitby light	54 30	0 37
River Tees', Seaton lights	54 40	1 12
Stockton	54 34	1 19
River Tyne's Mouth lights	55 1	1 25
Coquet Island	55 20	1 32
Staples light	55 39	1 40
Farn lights	55 37	1 39
Sunderland Point	55 36	1 38
Holy Island, Castle	55 40	1 47
BERWICK, Pier light	55 46	1 59
East Coast of Scotland.		
St. Abb's Head	55 55	2 8
DUNBAR	56 00	2 29
May Island lights	56 11	2 33
The Bass	56 5	2 38
N. Berwick	56 4	2 41
EDINBURGH	55 57	3 12
Ellyness	56 11	2 44
Fife Ness	56 17	2 35
St. Andrew's, Pier Head	56 20	2 47
Mouth of Tay light	56 27	2 38
Bell Rock, off do light	56 26	2 23
Buddonness lights	56 28	2 45
Red Head	56 37	2 29
Montrose light	56 42	2 27
Tod Head	56 51	2 14
NEW ABERDEEN	57 9	2 8
Newburgh	57 20	2 3
Peter Head, Pier light	57 30	1 46
Buchan Ness light	57 28	1 46
Ratrie Head	57 38	1 49
Kinnaird's Head light	57 42	2 0
Bamff light	57 40	2 31
Fort St. George	57 35	4 04
Inverness	57 29	4 13
Cromartie, Pt. light	57 41	4 0
Tarbet Ness light	57 51	3 48
Clythness	58 20	3 8
Noss Head light	58 29	3 3
Duncansby Head	58 40	3 8

XVI. *The Orkney Islands.*

Orkney Islands.	Lat. D. M.	Long. D. M.
Pentland Skerries light	58 41 N	2 55 W
Stromo	58 43	3 14
South Ronaldsha, S. p.	58 44	3 5
Copinsha	58 54	2 40
Lamb's Head on Stromsa Island	59 4	2 32
North Ronaldsha, N. p.	59 23	2 31
Mould Head, on Papa Westra Island	59 23	2 53
Noup Head, on Westra Isl.	59 20	3 04
Marwick Head, on Pomona Island	59 6	3 28
Stromness	58 57	3 18
Hoy Head, on Hoy Wells Island	58 55	3 31
Slue Skerry	59 3	4 16
Fair Island	59 33	1 38

XVII *The Shetland Islands.*

Shetland Islands.	Lat. D. M.	Long. D. M.
Sumbro Head, S. point lt.	59 51 N	1 16 W
Rose or Hangcliff	60 13	0 40
Brassa Sound, Lerwick	60 11	1 00
Out Skerries	60 37	0 8
Whalsey Isle	60 32	0 32
Unst Island, N. E. p.	61 7	0 15
Foul Island	60 9	2 06

XVIII. *Ferro Islands.*

Ferro Islands.	Lat. D. M.	Long. D. M.
The Monk Rock appears like a ship under sail	61 20 N	6 41 W
Fucloe Island, (N. E. part of Ferro,) E. pt.	62 20	6 13
East point of Mygenes Island, (N. W. part of Ferro Islands,)	62 3	7 32

XIX. *From Duncansby Head to the Land's End.*

North and West Coast of Scotland.	Lat. D. M.	Long. D. M.
Duncansby Head	58 40 N	3 1 W
Dunnet Head light	58 40	3 21
Farout Head	58 38	5 00
Cape Wrath, or Barre Head light	58 37	4 59
A Rock seen at ¾ ebb	58 45	5 21
Rona Island, Sum.	59 7	5 49
Rockal	57 35	13 40
St. Kilda	57 49	8 35
Butt of the Lewis	58 31	6 14
Gallen Head	58 14	7 02
Flannen Islands, N. W.	58 13	7 37
Hyskere Island	57 37	7 44
South Uist Island, E. pt.	57 13	7 10
Mingalay Island	56 48	7 33
Rea Head	57 54	5 33
Cana Island	57 3	6 38
Helsker Island	56 56	6 38
Rum Island, W. p.	56 59	6 30
Tirey Island, S. p.	56 27	6 56
Coll Island, N. p.	56 42	6 27
Skerryvore, Rock light	56 19	7 7
Illa Island, S. W. p.	55 47	6 24
——— S. p.	55 39	6 10
Mull of Cantire light-house	55 19	5 49
Pladda I. light off S. E. pt., Arran I.	55 26	5 7
Little Cumbrae light	55 43	4 55
GLASGOW	55 52	4 16
Elsa Island	55 20	4 55
Irvine	55 37	4 40
Air light	55 28	4 38
Loch Ryan light	54 58	5 2
Port Patrick light	54 50	5 7
Mull of Galloway light	54 38	4 51
Great Scar Island	54 40	4 36
Burrow Head	54 41	4 23
Solway Firth light	54 48	3 32
CARLISLE	54 54	2 56

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

West Coast of England.

	Lat. D.	Lat. M.	Long. D.	Long. M.
St. Bee's Head light	54	31 N	3	38 W
White Haven	54	33	3	36
Selker Rock	54	16	3	19
Lancaster	54	2	2	48
Formby light	53	31	3	10
LIVERPOOL, Obs.	53	25	3	0
Point of Air light	53	22	3	19
Great Orms Head	53	20	3	51
Point Linas light	53	25	4	17
Skerries light	53	25	4	37
Holyhead, Pier Hd. light	53	20	4	37
Branchy Pool Head	52	47	4	37
Bardsey Island light	52	45	4	48
Barmouth	52	43	3	52
Aberiswith light	52	25	4	05
Cardigan Harbor	52	6	4	38
Strumble Head	52	1	5	4
St. David's Head	51	55	5	20
Ramsay Island	51	52	5	22
Small's light-house	51	43	5	40
St. Ann's do., Milford Haven	51	41	5	10
St. Gowan's Head	51	36	4	56
Caldy Island, South light	51	38	4	41
Worm's Head	51	34	4	20
Mumble's Point and light	51	34	3	58
Nash Point, two lights	51	24	3	33
BRISTOL	51	27	2	35
Flatholm light	51	23	3	7
Lundy Island, entrance of Bristol Channel	51	10	4	40
Mort Point, entrance of Bristol Channel	51	[illegible]	4	14
Hartland Point	51	1	4	32
Padstow	50	33	4	56
Cow and Calf	50	33	5	5
Towan Head	50	25	5	9
St. Ive's Bay, Pier Hd. lt.	50	12	5	28
Cape Cornwall	50	8	5	42
The Seven Stones light	50	2	6	7
The Wolf Rock	49	57	5	48
The Land's End	50	4	5	42

XX. *Ireland.*

West Coast of Ireland.

	Lat. D.	Lat. M.	Long. D.	Long. M.
CAPE CLEAR light	51	26 N	9	29 W
Fastnet Rock light	51	24	9	36
Crook Haven light	51	29	9	43
Mizen Head	51	27	9	50
Sheep's Head	51	33	9	52
Bantry Bay	51	35	9	53
Grelagh Rocks	51	31	10	10
Dursey Island, W. p.	51	35	10	14
Bull Rock	51	36	10	18
Cow do.	51	35	10	17
Cod's Head	51	40	10	08
Kenmare Bay	51	43	10	[illegible]
Lamb's Head	51	45	10	08
Scara Islands	51	44	10	15
Hog's Head	51	47	10	13
Bolus Head	51	47	10	20
Skellig's Rocks lights	51	46	10	32
Lemon Rock	51	48	10	26
Bray Head	51	53	10	25
Dingle Bay	52	00	10	27
Foze Rock	52	1 N	10	40 W
Inishmakillaan	52	2	10	36
Tiraght Rocks	52	3	10	39
Great Blasket, N. pt.	52	6	10	31
Inishluiskero	52	7	10	35
Dunmore Head	52	5	10	28
Dunorling Head	52	12	10	25
Brandon Head	52	17	10	10
The Seven Hogs Rocks	52	20	10	04
Kerry Head, S. entrance of Shannon River	52	23	9	55
Loop Head, Light	52	34	9	56
LIMERICK Bridge	52	40	8	39
Clare	52	51	9	32
Hog's Head	53	5	9	43
North Arran, or Killaney, lt.	53	8	9	42
Galway light	53	15	9	3
Slyne Head Light	53	29	10	16
Ennis Shark Island	53	46	10	36
Ennis Turk Island	53	52	10	21
Clare Island Light	53	50	9	59
Achil Head	53	59	10	16
Black Rock outer	54	4	10	22
Urris Head Eagle, Id.	54	16	10	6
Broad Haven	54	26	10	12
Tuns Rocks, off Broad Haven	54	3[illegible]	10	4

North Coast of Ireland.

	Lat. D.	Lat. M.	Long. D.	Long. M.
Down Patrick Head	54	20	9	21
Killala	54	11	9	13
Sligo Bay Light, Black R.	54	18	8	37
Ennis Murray Island	54	26	8	40
Donnegal	54	39	8	6
Tillon Head	54	41	8	46
Arran N. P.	55	1	8	33
Bloody Foreland Hill	55	8	8	16
Tory Island lights	55	16	8	15
Hoar Head	55	13	7	57
Mulroy	55	17	7	48
Loch Swilley, Fannet pt.	55	17	7	38
Malliny Head light	55	23	7	22
Ennistrahul Rocks light	55	26	7	14
Inishone Head, entrance of Londonderry lights	55	14	6	56
LONDONDERRY Bridge	55	00	[illegible]	19
Giant's Causeway, pt.	55	15	6	30
Rathlin Island, light	55	18	6	11
Fair Head	55	13	6	8
Torr Point	55	12	6	4

East Coast of Ireland.

	Lat. D.	Lat. M.	Long. D.	Long. M.
The Maid's Rocks light	54	56	5	45
Black Head	54	46	5	41
Carrickfergus	54	43	5	48
BELFAST	54	35	5	57
Belfast L. Hollywood B. lts.	54	39	5	53
Mew Island lights	54	42	5	25
South Rock light	54	24	5	26
Dundrum	54	17	5	51
Carlingford Loch light	54	2	6	8
Dundalk	54	0	6	24
Drogheda Bar	53	44	6	12
St. Patrick's Island	53	36	6	03
Lambay Island	53	29	6	00
Howth Farb. E. Pier Hd. lt.	53	24	6	4
DUBLIN observatory	53	23.2	6	20½
WICKLOW lights	52	58	6	0
Arklow Light	52	42	6	0
Glasscarrick	52	34	6	10

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat. D.	Lat. M.	Long. D.	Long. M.
South Coast of Ireland.	WEXFORD, Raven pt.	52	20 N	6	21 W
	Tusker Rock light	52	12	6	12
	Carnsore Point	52	11	6	23
	The Saltees Rocks light	52	2	6	40
	Hook light, Waterford harbor	52	7	6	56
	Dungarven	52	05	7	38
	Helwick Head point	52	03	7	33
	Youghall light	51	56	7	52
	CORK harbor light	51	48	8	15
	Kingsale harbor light	51	42	8	30
	Old Head of Kingsale lights	51	37	8	32
	Seven Heads	51	34	8	44
	Dundedy Head	51	32	8	58
	The Stags, off Toe Head	51	28	9	14
	BALTIMORE harbor	51	29	9	22

XXI. *The Isle of Man.*

		Lat. D.	Lat. M.	Long. D.	Long. M.
Isle of Man.	Calf of Man lights	54	3 N	4	50 W
	Douglass lights	54	9	4	28
	Ramsey harb. light S. side	54	20	4	23
	Point of Air	54	25	4	22
	Peel harb. light E. side	54	13	4	42
	Castletown harb. light	54	5	4	37

XXII. *From Calais to the Scaw.*

		Lat. D.	Lat. M.	Long. D.	Long. M.
N. of France.	CALAIS	50	58 N	1	51 E
	Gravelines	50	59	2	7
	DUNKIRK Pier hd. light.	51	3	2	22
	Nieuport	51	8	2	45
	OSTEND	51	14	2	55
	Sluys	51	19	3	23
	ANTWERP	51	13	4	24
Holland.	Walcheren Island, W. p.	51	32	3	28
	——— FLUSHING	51	27	3	35
	——— Middleburgh	51	30	3	37
	Goeree Island	51	46	3	52
	Schowen Island light	51	43	3	42
	Holland's Hook	51	56	4	00
	The Hague	52	4	4	18
	Leyden obs.	52	9	4	29
	Haerlem	52	22	4	38
	ROTTERDAM	51	54	4	29
	AMSTERDAM	52	22	4	53
	Alkmaer	52	38	4	45
	Texel, S. point	53	2	4	33
	Harlingen	53	10	5	20
	Ter Schelling, W. end	53	22	5	12
Germany.	Gottingen, obs.	51	32	9	53
	EMBDEN	53	22	7	12
	Borcum light	53	36	6	41
	Wranger-oog light	53	48	7	52
	BREMEN	53	5	8	49
	Bremerlehe	53	32	8	32
	HAMBURGH	53	33	9	58
	Stade	53	36	9	28
	Glukstadt	53	48	9	25
	Cuxhaven light	53	54	8	43
	Nework	53	55	8	30
Denmark.	Elbe River, entrance	54	00 N	8	20 E
	Heligoland light	54	12	7	53
	Tonningen	54	19	9	5
	Horn Point	55	34	7	40
	Holmen	57	8	8	34
	Robsnout	57	25	9	34
	SCAW light	57	43	10	37

XXIII. *Cattegat and Sound.*

		Lat. D.	Lat. M.	Long. D.	Long. M.
Jutland.	SCAW LIGHT	57	43 N	10	37 E
	Fladstrand	57	26	10	32
	Sebye	57	20	10	31
	Halls	57	00	10	19
	Grenaa	56	26	10	53
	Aarhus cath.	56	9	10	13
	Sleswick	54	32	9	33
Norway.	The NAZE light	57	58	7	02
	Christiansand	58	9	7	59
	Arendal, Torungen light	58	23	8	53
	Frederickavern	58	59	10	12
	Ferder light	59	2	10	32
	CHRISTIANA obs.	59	55	10	43
	Frederickstadt	59	12	11	0
	Stronstadt	58	55	11	12
	Salo Beacon	58	21	11	14
Sweden.	Paternosters	57	55	11	27
	Marstrand light	57	53	11	35
	GOTHENBURGH	57	42	11	55
	Wingo Beacon	57	38	11	36
	Tislarne	57	30	11	44
	Niddingen lights	57	18	11	55
	Warberg	57	6	12	15
	Falkenburg	56	55	12	30
	Halmstadt fort	56	40	12	52
	Laholm	56	32	13	00
	Wadero Island, S. end	56	26	12	35
	Engelholm	56	14	12	52
	Koll light	56	18	12	28
	Helsinborg	56	2	12	42
	Landskrone	55	52	12	50
	Malmo	55	36	13	1
	Falsterbo light	55	23	12	49
Zealand.	Steffen's Head light	55	18	12	27
	Kioge	55	28	12	12
	COPENHAGEN	55	41	12	34
	ELSINEUR	56	2	12	37
	Cronenburg light	56	3	12	37
	Nakke Head lights	56	7	12	22
	Nykoping	55	55	11	40
	Callundborg	55	41	11	6
	Corsor lights	55	20	11	9
	Wordingborg	55	1	11	59
	Huen Island, Uraniberg	55	55	12	43
	Amag Island, Drago	55	35	12	38
	Hasel Island	56	12	11	44
	Spro Island light	55	20	10	57
	Falster Island, Geedesbye or Trindelen light	54	34	11	59
	Moen Island, Speil Cliff	54	58	12	34
	Anholt light	56	44	11	39
	Little Middle Ground	56	57	11	59
	Lessoe Island, E. end	57	19	11	9

TABLE LIV.

Latitudes and Longitudes.

Place	Lat. D. M.	Long. D. M.
Lessoe Island, W. end	57 15 N	10 50 E
Trindelen light	57 26	11 16

XXIV. *The Baltic.*

	Place	Lat. D. M.	Long. D. M.
Denmark Islands.	Funen, Odense	55 25 N	10 24 E
	——— Nyborg	55 19	10 48
	Langeland S. pt.	54 42	10 42
	Aero, Kiop	54 54	10 28
	Alsen, Sonderborg	54 56	9 52
	Laaland, Naskou	54 51	11 15
	——— Nysted	54 42	11 48
	Falster Nikioping	54 47	11 54
	——— Stubbekioping	54 54	12 8
	Moen, Stege E. pt.	54 57	12 33
	Fermeren, Borg	54 28	11 17
Sweden.	Tralleborg	55 22	13 11
	Cimbrishamn	55 34	14 21
	Ahus	55 56	14 18
	CARLSCRONA	56 10	15 36
	Torum Point	56 5	15 53
	Calmar	56 40	16 20
	Westerwyck	57 46	16 38
	Soderkoping	58 30	16 20
	Nykoping	58 46	17 3
	Trosa	58 54	17 33
	Landsort light	58 44	17 53
	STOCKHOLM	59 21	18 4
German Coast.	Kiel	54 21	10 10
	LUBECK	53 52	10 42
	Wismar	53 54	11 26
	Rostock	54 6	12 5
	Dars Head	54 28	12 31
	Geblen light	54 28	13 12
	Stralsund	54 18	13 6
	Grifswaldœ light	54 15	13 56
	Usedom	53 53	14 5
	Wollin	53 49	14 41
	Stettin	53 25	14 34
	Cammin	53 57	14 50
	Colberg fort	54 11	15 38
	Rugenvalde	54 23	16 25
	Stolepemunde	54 30	16 50
	Heel light	54 37	18 46
	DANTZIG obs.	54 22	18 41
	Pillau light	54 38	19 54
	KONIGSBERG obs.	54 43	20 30
	Brusterort lights	54 58	19 59
	Memel	55 44	21 6
Russian Coast.	Libau	56 32	20 57
	Windau	57 24	21 34
	Lyserort	57 35	21 45
	Domesness lights	57 46	22 37
	Runo Island light	57 48	23 11
	RIGA	56 57	24 6
	Pernau	58 23	24 30
	Dago, Simperness	59 6	22 32
	——— Dagerort light	58 56	22 12
	Osel, Palmerort	58 39	22 28
	——— Hundsort	58 32	21 50
	——— Swasveort light	57 55	22 5
	——— Arensburgh	58 15	22 28
	Gottska Sando W. pt.	58 22	19 19
	Faro, N. E. end	57 56	19 26
	Gotland, N. E. end	57 51	19 2

	Place	Lat. D. M.	Long. D. M.
Islands of the Baltic.	Gotland, WISBY	57 39 N	18 20 E
	——— Hoburg	56 57	18 9
	Great Carlso	57 19	18 2
	Oland, N end	57 22	17 7
	——— Borgholms Slott	56 52	16 37
	——— S. end light	56 12	16 26
	Eartholms	55 19	15 12
	Bornholm, N. W. end, ——— light	55 18	14 47
	——— Hasle	55 10	14 47
	——— S. E. end	54 58	15 12
	——— Svaneke	55 8	15 13
	Rugen, N. end	54 40	13 30
	——— BERGEN	54 25	13 28
	——— S. E. end New Deep	54 16	13 50

XXV. *Gulfs of Finland and Bothnia.*

	Place	Lat. D. M.	Long. D. M.
Russia.	Odensholm light	59 19 N	23 22 E
	Packerort light	59 24	24 0
	Surep Head light	59 28	24 23
	Nargen Island, N. point	59 36	24 32
	REVEL	59 26	24 46
	Kokskar light	59 42	25 2
	Chalk Ground	59 41	26 9
	Stone Skar beac.	59 49	26 21
	Little Tyters Island	59 48	26 58
	Great Tyters Island	59 50	27 15
	Lavanscar, N. end	60 2	27 52
	Seskar light	60 02	28 23
	Narva	59 20	28 4
	Dolgoinos	59 54	29 0
	Tolbaken light	60 2	29 34
	CRONSTADT cath.	59 59	29 47
	PETERSBURG	59 56	30 19
	Stirsudden	60 12	29 0
	Wiburg	60 43	28 46
	Fredericksham	60 34	27 16
	Aspo beac.	60 18	27 13
	Hogland Island, N. light	60 5	27 00
	Orrenground's Beacon	60 17	26 27
	Lovisa	60 27	26 16
	Borgo	60 21	25 45
	Helsingfors	60 10	24 58
	Great Jussari	59 50	23 33
	Hango Beacon	59 45	22 57

XXVI. *Gulf of Bothnia.*

	Place	Lat. D. M.	Long. D. M.
Bothnia.	Uto light	59 47 N	21 22 E
	Abo	60 27	22 17
	Wasa	63 4	21 43
	TORNEA	65 51	24 14

XXVII. *From the Naze to Archangel.*

Place	Lat. D. M.	Long. D. M.
The NAZE	57 58 N	7 3 E
Lister Land	58 6	6 36

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat.		Long.	
		D.	M.	D.	M.
Norway.	Judder, or Walbert's Head	58	36 N	5	40 E
	Great Wylingose light-house	59	4	5	26
	Stavanger	58	59	5	45
	Bommel Island, S. end	59	35	5	11
	BERGEN	60	24	5	18
	Askwold	61	22	5	12
	Ronde light	62	25	5	36
	Christiansund light	63	7	7	39
	Drontheim	63	26	10	23
	Werro Island	67	42	11	41
Lapland.	NORTH CAPE	71	10	25	46
	Wardhuus Island	70	23	31	7
	River Kola	68	52	33	1
	Nagel Island	68	32	38	0
	Sviatoi Noss Tower	68	10	39	47
White Sea.	Cape Orlogenose	67	14	41	22
	Cross Island	66	28	40	28
	Onega Church	63	54	38	8
	Cape Donega	65	8	36	47
	ARCHANGEL	64	32	40	33
	Bluenose, or Cape Katness	65	26	39	54
	Cape Good Fortune	66	31	42	53
	Morshovet's Island, S. pt.	66	40	43	27
	Cape Candinose	68	39	44	33
	Welgate's Straits	70	50	57	45
	Nova Zembla	76	34	62	45

XXVIII. *From Ushant to Gibraltar.*

		Lat.		Long.	
		D.	M.	D.	M.
West Coast of France.	USHANT light	48	29 N	5	3 W
	BREST	48	23	4	29
	St. Matthew's light	48	20	4	44
	Point Raz light	48	2	4	44
	Saints' Rocks	48	4	5	5
	Point L'Abbe	47	49	4	12
	Quimper	47	58	4	8
	Glenan Islands	47	44	4	00
	Quimperlay	47	52	3	34
	L'ORIENT	47	45	3	21
	Port Louis	47	43	3	21
	Isle de Groas lt. N. W. pt.	47	39	3	30
	Quiberon, S. point	47	26	3	4
	Belle Isle, N. end	47	23	3	14
	——— S. end	47	17	3	5
	Vannes	47	39	2	46
	Houat Isle	47	24	2	56
	Dumet Isle	47	22	2	36
	NANTES	47	13	1	33
	Croisic	47	18	2	31
	St. Gildas Point	47	10	2	16
	Noirmoutier Island, S. W.	47	00	2	15
	Isle D'Yeu light	46	43	2	23
	St. Gilles	46	41	1	56
	Roches Bonnes W.	46	15	2	24
	Isle of Rhe light N. W. pt.	46	15	1	34
	ROCHELLE light	46	9	1	9
	ROCHEFORT	45	56	0	58
	Oleron Isle light	46	3	1	24
	Island Aix light at S. pt.	46	1	1	11
	CORDOUAN light	45	35	1	10
	Medoc	45	6	0	45
	BORDEAUX	44	50	0	34
	Cape Feret light	44	39	1	14
	BAYONNE	43	29	1	29
North Coast of Spain.	St. John de Luz	43	23 N	1	38 W
	St. Sebastian light	43	20	2	00
	Cape Machichaco	43	28	2	49
	BILBAO	43	15	2	54
	Santona	43	27	3	26
	SANTANDER light	43	30	3	47
	St. Vincent	43	30	4	16
	Villa Viciosa	43	28	5	18
	Cape Penas	43	42	5	46
	Ribadeo, entrance	43	35	7	05
	Cape Burela	43	42	7	21
	Cape Vares	43	47	7	41
	Cape Ortegal	43	45	7	56
	Cape Prior	43	34	8	19
	FERROL	43	30	8	13
	CORUNNA light	43	22	8	24
	Cape Villano	43	10	9	15
	Cape Turiana	43	3	9	21
	Cape Finisterre	42	54	9	21
	Point Corrobedo	42	35	9	7
	Vigo light in castle	42	15	8	40
	Cape Fasalis	41	59	8	45
Portugal.	OPORTO light	41	09	8	37
	Averios	40	39	8	36
	Coimbra	40	13	8	24
	Cape Mondego	40	12	8	54
	Cape Fiseraon	39	24	9	18
	The Burlings light	39	25	9	30
	Cape Carboeiro light	39	21	9	24
	The Rock of Lisbon	38	46	9	29
	LISBON	38	42	9	9
	Cape Espichel light	38	24	9	13
	St. Ubes	38	32	8	50
	Cape Sines fort	37	57	8	53
	Cape St. Vincent light	37	3	9	0
	Lagos	37	8	8	39
	Cape Carbonera	37	7	8	19
	Cape St. Mary	36	57	7	52
South Coast of Spain.	Point Arenilla	37	8	6	50
	St. Lucar	36	44	6	24
	SEVILLE	36	59	5	58
	CADIZ light	36	32	6	18
	Cape Trafalgar	36	10	6	00
	Tarifa Island light	36	0	5	37
	Point Carnero	36	5	5	23
	Algesiras mole	36	8	5	26
	GIBRALTAR mole	36	7	5	21

XXIX. *North Coast of the Mediterranean Sea, from Gibraltar to Constantinople.*

		Lat.		Long.	
		D.	M.	D.	M.
South Coast of Spain.	GIBRALTAR, ——— Europa Point	36	7 N	5	22 W
	Cape Morat	36	31	4	38
	MALAGA mole	36	43	4	26
	Corchuna castle	36	42	3	25
	Almeria	36	51	2	31
	Cape de Gatt, —— Coralletes tower	36	44	2	12
	Cape Tinosa	37	31	1	10
	CARTHAGENA, obs.	37	36	1	1
	Escombrera Island	37	34	0	57
	Cape de Palos	37	37	0	41
	Cape Cervera, ——— Torre Vieja	37	59	0	41
	Cape Santa Pola	38	12	0	29

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat. D.	Lat. M.	Long. D.	Long. M.
South Coast of Spain.	ALICANTE	38	20 N	0	26 W
	Cape St. Martin	38	47	0	10 E
	Cape Cullera tower	39	12	0	13 W
	VALENCIA, city	39	28	0	24
	Cape Oropera tower	40	6	0	10 E
	River Ebro, ——— Buda Island	40	43		
	Cape Salou	41	5	1	11
	TERRAGONA	41	9	1	18
	BARCELONA	41	23	2	11
	Cape Tosa	41	43	2	58
	Cape St. Sebastian	41	54	3	13
	Medas Isles, S. end	42	3	3	13
	Gulf of Rosas, Cape Norfeo	42	15	3	17
	Cape Creux	42	20	3	20
South Coast of France.	Port Vendre	42	32	3	6
	Perpignan	42	42	2	54
	Narbonne	43	11	3	0
	Agde harb.	43	17	3	28
	Cetta light	43	24	3	41
	Montpellier, obs.	43	36	3	53
	St. Louis's tower, W. mouth of the Rhone	43	21	4	41
	Cape Couronne	43	19	5	2
	MARSEILLES, obs.	43	18	5	22
	Planier Island light	43	12	5	14
	Cape Roux	43	13	5	20
	Ciotat	43	10	5	36
	Cape Sicie	43	3	5	50
	TOULON	43	7	5	56
	Hyeres Islands, ——— Porquerolles, Fort Langoustier	43	0	6	12
	——— Portcross, Gabiniere Rock	42	59	6	23
	——— Titan, E. point	43	2	6	30
	Cape Taillat	43	8	6	41
	St. Tropez	43	15	6	34
	Frejus	43	26	6	46
	Antibes	43	35	7	8
North Coast of Italy.	Nice	43	41	7	17
	Villa Franca light	43	40	7	20
	Ventimiglia Point	43	44	7	43
	Port Maurizio, mole	43	53	8	0
	Cape de la Melle	43	58	8	11
	Cape Noli	44	11	8	23
	Savona, mole	44	18	8	28
	Polla Rock	44	25	8	46
	GENOA light	44	24	8	53
	Cape Porto Fino	44	18	9	15
	Cape dell Mesco	44	8	9	40
	Port Venere	44	4	9	52
West Coast of Italy.	Pisa, obs.	43	43	10	24
	FLORENCE	43	46	11	16
	Melora Shoal tower	43	33	10	13
	LEGHORN light	43	32	10	18
	Mal di Vetro Shoal	43	20	10	22
	Piombino, mole	42	55	10	32
	Castiglione tower	42	45	10	55
	Mount Argentaro	42	22	11	12
	Civita Vecchia light	42	5	11	45
	Cape Linaro	42	1	11	50
	Fiumicino light, R. Tiber	41	46	12	12
	ROME, St. Peter's	41	54	12	27
	Port Anzo, mole	41	27	12	42

		Lat. D.	Lat. M.	Long. D.	Long. M.
	Cape Monte Circello	41	12 N	13	5 E
Coast of Naples.	Gaeta, mole	41	12	13	36
	Cape Miseno	40	46	14	5
	NAPLES light	40	50	14	16
	Salerno	40	40	14	45
	Cape Licosa tower	40	14	14	53
	Policastro	40	2	15	33
	St. Euphemia	39	3	16	15
	Cape Vaticano	38	37	15	52
	Scylla castle	38	14	15	44
	Cape dell Armi tower	37	58	15	42
	Cape Spartivento	37	56	16	3
S. Coast of Italy.	Cape Stilo	38	28	16	37
	Cape Rizzuto	38	57	17	1
	Cape Nau or Collone	39	6	17	14
	Point del Tronta tower	39	35	16	47
	Tarento, St. Pietro Island	40	26	17	9
	Gallipoli, St. Andrea Island	40	2	17	57
	Cape St. Maria, convent	39	49	18	23
Adriatic, or the Gulf of Venice.	Cape Otranto, tower	40	8	18	30
	Brindisi, fort	40	39	18	1
	Polignano	41	0	17	15
	Bari, mole	41	9	16	54
	Barletta light	41	20	16	19
	Manfredonia, mole	41	38	15	56
	Viesti Groce Island	41	53	16	12
	Termoli	42	00	15	00
	Point Penna	42	10	14	44
	Ortona, mole	42	21	14	28
	Pedaso	43	6	13	51
	ANCONA light	43	38	13	30
	Fano light	43	51	13	1
	Pesaro light	43	56	12	55
	Rimino light	44	5	12	34
	RAVENNA, tower	44	25	12	12
	Point della Maestra	44	59	12	32
	VENICE, St. Mark's tower	45	26	12	21
	Port Lignano	45	41	13	11
	TRIESTE, castle	45	39	13	46
	Point Salvore light	45	30	13	33
	Rovigno	45	5	13	38
	Cape Promontore	44	46	13	55
	Fiume	45	20	14	27
	Segna, mole	45	00	14	54
	Karlopago, mole	44	32	15	5
	Zara	44	7	15	13
	Sabenico	43	44	15	53
	Spalatro, Paulino tower	43	30	16	26
	RAGUSA, mole	42	38	18	7
	Kattaro, Point Ostro	42	23	18	31
	Dulcigno, mole	41	54	19	12
	Cape Rodoni	41	38	19	29
	Cape Pali	41	23	19	25
	Durazzo, mole	41	18	19	28
	Aulona, or Valona	40	27	19	26
	Cape Linguetta	40	27	19	18
Albania.	Butrinto	39	47	20	4
	Parga, town	39	17	20	23
	Previsa, Fort Pantokratera	38	56	20	44
	Oxia Island, S. end	38	17	21	6
	Missolonghi fort	38	21	21	24
	Roumelia castle	38	19	21	46
	Lepanto	38	22	21	51
	CORINTH	37	54	22	52

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

Region	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
Morea.	Patras, mole	38	14 N	21	46 E
	Cape Papas	38	13	21	26
	Tornese castle	37	54	21	10
	Cape Catakolo	37	38	21	20
	Cape Konello	37	12	21	35
	Navarino castle	36	53	21	41
	Coron, or Koron	36	47	22	00
	Cape Matapan	36	22	22	28
	Cape St. Angelo	36	26	23	13
	Nauplia, or Napoli di Romania	37	34	22	48
Eastern Coast of Greece.	ATHENS, Philopapus	37	58	23	44
	Cape Colonna	37	39	24	2
	Cape Marathon	38	07	24	5
	Negropont, fort	38	28	23	35
	Cape Doro	38	10	24	36
	Cape Kili	38	40	24	10
	SALONICA	40	39	22	57
	Cape Drepano	39	57	23	57
	Cape Paillouri	39	55	23	46
	Mount Athos	40	9	24	20
	Contessa	40	50	23	52
	Cape Paxi	40	37	26	5
	The Dardanelles	40	2	26	12
	Gallipoli light	40	25	26	40
Sea of Marmora.	CONSTANTINOPLE, St. Sophia	41	1	28	59
	Scutari	41	1	29	1
	Prince's Isles, westernmost	40	52	28	59
	Marmora Island, S. W. end	40	37	27	35
	——— E. end, light	40	38	27	46

XXX. *The Black Sea and Sea of Azof.*

Region	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
Black Sea.	Bosphorus, European light	41	14 N	29	7 E
	Bourgas City	42	29	27	28
	VARNA, S. E. bastion	43	12	27	56
	Cape Calaghriah	43	21	28	29
	Mouths of the Danube, Soulineh light	45	10	29	41
	Ackerman	46	12	30	22
	ODESSA	46	28	30	44
	Kherson	46	38	32	39
	Tendra Island light	46	19	31	29
Crimea.	Cape Tarkan light	45	22	32	31
	Koslof	45	11	33	21
	Cape Chersonesus light	44	34	33	21
	Sevastopol	44	37	33	30
	Cape Karak	45	2	36	18
Sea of Azof.	Taganrok, Church	47	13	38	57
	AZOF	47	7	39	26
	Sougoudjak	44	39	37	47
Black Sea.	Poti, or Phaz, new fort	42	8	41	40
	Trebizonde	41	1	39	45
	Cape Vona	41	7	37	49
	SINOPE	42	3	35	12
	Heraclea light	41	17	31	25
	Bosphorus, Asia light	41	13	29	9

XXXI. *The East and South Coast of the Mediterranean.*

Region	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
Turkey.	Cape Janissary	40	1 N	26	13 E
	Cape Baba	39	29	26	5
	Adramytti	39	36	27	2
	SMYRNA	38	26	27	7
	Cape Karabouroun	38	40	26	23
	Cape Koraka	38	6	26	37
	Cape St. Mary	37	39	27	4
	Cape Crio	36	42	27	21
	Gulf of Makry, Cape Iria	36	33	29	2
	Seven Capes	36	24	29	10
	Cape Khilidonia	36	12	30	26
	Cape Karaboornoo	36	38	31	43
	Cape Anamour	36	1	32	49
	Cape Cavaliere	36	8	33	43
	Point Lissan el Kabeh	36	12	33	59
	Karadash Boornoo	36	33	35	21
Egypt.	Scanderoon, or Alexandretta	36	35	36	15
	Cape Khynzyr	36	16	35	52
	ALEPPO	36	11	37	10
	Latakia	35	31	35	46
	Tortosa	34	50	35	50
	Tripoli	34	26	35	49
	Cape Bairout	33	50	35	28
	Acre	32	54	35	6
	Jaffa	32	3	34	44
	El Arish	31	6	33	56
	Damietta	31	25	31	47
	Cape Bourlas	31	35		
	CAIRO	30	3	31	18
	Rosetta	31	25	30	28
	Aboukir, tower	31	21	30	6
	ALEXANDRIA light	31	12	29	53
	Ras al Kanais	31	16	27	52
Tripoli.	Tifarh Rocks	31	36	26	16
	Cape Luko	31	52	25	3
	Bomba, port of, Bhurda Island	32	23	23	16
	Cape Razatin	32	34	23	13
	Derna	32	46	22	41
	Cape Razat	32	56	21	39
	Bengasi, castle	32	7	20	3
	Gharra Island	30	47	19	57
	Kudia	30	44	18	18
	Boosaida	31	00	17	39
	Shaiusha	31	10	17	10
	Cape Mesurata, N. extreme	32	25	15	10
	Ziliten	32	30	14	34
Tunis.	TRIPOLI, castle	32	54	13	11
	Zoara	32	55	12	4
	Jerba Island, Zug castle	33	53	10	53
	Kabes	33	53	10	4
	Karkenna Islands, Kusha Island	34	49	11	19
	Cape Burdj Kadija	35	10	11	10
	Soussa, mole	35	48	10	39
	Cape Bon, N. point	37	6	11	3
	Zembra Island, middle	37	9	10	49
	TUNIS, city	36	47	10	6

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat. D.	Lat. M.	Long. D.	Long. M.
Tunis.	Point Farina	37	11 N	10	15 E
	Piana Island	37	11	10	18
	Cape Bianco	37	20	9	48
	Cape Serrat	37	14	9	10
	Tabarca Island	36	56	8	43
Algiers.	Cape Ross	36	55	8	13
	Cape Mavera	36	58	7	50
	Bona, town	36	54	7	48
	Cape Ferro	37	6	7	11
	Capes Bugaroni	37	7	6	29
	Cape Carbon	36	47	5	5
	Cape Dellys or Tedilles	36	55	4	9
	Cape Bingut	36	57	3	55
	Cape Matafou	36	51	3	12
	ALGIERS light	36	47	3	4
	Cape Tennez	36	33	1	21
	Cape Kulmeta	36	16	0	27
	Cape Ferrat	35	55	0	18 W
	Cape Falcon	35	48	0	48
	Cape Figalo	35	31	1	10
	Cape Guardia	35	18	1	41
Morocco.	Cape Tres Forcas	35	28	3	0
	Al Buzema, — Garrison Rock	35	17	3	47
	Pescadores	35	16	4	45
	Cape Tetuan	35	33	5	15
	Cape Negro	35	42	5	17
	Ceuta, Almina Point	35	54	5	17
	TANGIER	35	47	5	50
	Cape Spartel	35	48	5	54

XXXII. *Islands in the Mediterranean, Gulf of Venice, and Archipelago.*

		Lat. D.	Lat. M.	Long. D.	Long. M.
	Alboran Isle	35	59 N	3	1 W
	Formentera, — Point del Aguila	38	38	1	23 E
	— La Mola, or E. pt.	38	39	1	35
	IVICA, — Point den Serra, N. p.	39	8	1	32
	— Cape Nono	39	3	1	23
	— Bedra Island	38	51	1	12
	Cabrera Island, — Point Anciola	39	5	2	53
Majorca.	MAJORCA, — Point Rebagada, W. pt.	39	34	2	23
	— Cape Cala Figuera	39	28	2	31
	— Palma, town	39	34	2	39
	— Cape Salinas, S. point	39	14	3	5
	— Cape de Pera, E. point	39	42	3	27
	— Cape Formenton, N. pt.	39	57	3	15
Minorca.	MINORCA, — Cape Dartuch	39	56	3	51
	— Cape Minorca	40	3	3	51
	— PORT MAHON, Cape Mola	39	53	4	23
	— S. E. point	39	47	4	20
	Cape del Testa or Longo Sardo, N. end	41	14	9	9
	Asinara Island, N. E. end	41	8	8	18
Sardinia, &c.	Cape Falcone	40	59 N	8	11 E
	Cape Caccia	40	33	8	5
	Mal di Ventri Island	39	59	8	16
	Cape St. Marco	39	51	8	26
	Cape Frasco	39	46	8	27
	St. Pietro Island, Carlo fort	39	9	8	17
	St. Antioco Island, S. pt.	38	58	8	26
	Toro Rock	38	52	8	25
	Cape Teulada	38	52	8	39
	CAGLIARI, mole	39	12	9	7
	Cape Carbonara, — Cavoli Island, tower	39	6	9	32
	Montorio Island, N. E. pt.	41	5	9	36
	Madelaine Island, N. pt.	41	16	9	25
Corsica.	Giraglia Island, tower	43	2	9	24
	Cape Corso, N. pt.	43	1	9	23
	St. Fiorenzo	42	41	9	18
	Calvi	42	33	8	45
	Cape Turghia, tower	42	14	8	33
	Ajaccio	41	55	8	44
	Bonifacio, tower	41	23	9	9
	Port Vecchio	41	35	9	20
	BASTIA	42	42	9	27
Italian Islands.	Gorgona, tower	43	25	9	52
	Capraja, middle	43	3	9	50
	ELBA, — Port Ferragio	42	49	10	20
	— Cape Dorana	42	48	10	6
	Pianosa, N. point	42	35	10	7
	Africa Rocks, or West Formiches	42	21	10	8
	Monte Christo, middle	42	20	10	20
	East Formiches	42	37	10	53
	Giglio Island, middle	42	20	10	58
	Gianuti, middle	42	14	11	9
	Palmarola, N. pt.	40	57	12	52
	Ponza, S. pt.	40	53	12	58
	Botte Rock	40	50	13	6
	Vandotena, N. end	40	48	13	26
	Ischia, S. pt.	40	40	13	56
	Capri, Point Carena	40	31	14	12
Sicily.	Faro light, N. E. pt.	38	16	15	41
	MESSINA light	38	12	15	35
	Taormina	37	48	15	18
	Catania, mole	37	28	15	5
	Syracuse light	37	3	15	17
	Cape Passaro, S. E. pt.	36	40	15	8
	Cape Scalambra, town	36	46	14	30
	Alicata castle	37	4	13	56
	Cape Bianco	37	22	13	16
	Cape St. Marco	37	29	13	00
	Cape Granitola	37	34	12	37
	Cape Boco, W. point	37	48	12	25
	TRAPANI light	38	3	12	30
	Cape St. Vito, N. W. pt.	38	12	12	46
	Cape di Gallo	38	15	13	19
	PALERMO light	38	8	13	22
	Cape Zaffarana	38	6	13	34
	Cefalu, cathedral	38	0	14	4
	Cape Orlando	38	8	14	45
	Melazzo light	38	16	15	14
	EOLIAN ISLANDS, — Stromboli	38	48	15	13
	— Panaria, S. W. pt.	38	38	15	3

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

Region	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
Sicilian Islands.	EOLIAN ISLANDS,				
	—— Lipari, castle	38	28 N	14	58 E
	—— Vulcano	38	23	14	56
	—— Salina, N. part	38	36	14	48
	—— Felicudi	38	34	14	30
	—— Alicudi	38	33	14	17
	—— Ustica	38	43	13	11
	ÆGADIAN ISLES,				
	—— Maritimo, castle	38	0	12	4
	—— Levanso	38	2	12	20
	—— Favignana, castle	37	57	12	18
	Pentellaria, fort	36	51	11	54
	Linosa	35	52	12	52
	Lampedusa	35	29	12	35
	Lampion	35	33	12	19
	Goza, N. W. point	36	4	14	8
	MALTA, Valetta	35	54	14	30
	——— Point Benhisa	35	49	14	33
	——— Tefola Rock	35	47	14	29
	Esquerque or Skirki Rocks, middle	37	46	10	47
	Keith's Reef	37	50	10	56
	Galita	37	31	8	55
	Sorelli Rocks	37	25	8	37
Islands in the Gulf of Venice.	Unie	44	38	14	15
	Premuda	44	20	14	37
	Ulbe, mole	44	23	14	47
	Grossa, or Lunga, ——— Punta Bianchi	44	9	14	50
	Brazza, W. end	43	19	16	27
	Pomo Rock	43	5	15	28
	Busi, signal	42	58	16	1
	Lissa	43	3	16	12
	Lessina, Fort Imperial	43	11	16	27
	Curzola, ——— St. Giovanni di Bl.	42	58	16	41
	Cazza	42	46	16	31
	Lagosta, ——— Mount St. Georgio	42	45	16	52
	Meleda, Point Grui	42	41	17	45
	Pelagosa, signal	42	24	16	16
	Cajola Rock	42	23	16	22
	Pianosa, signal	42	14	15	45
	Tremiti, St. Nicola	42	8	15	31
Ionian Islands.	Fano, N. W. pt.	39	52	19	19
	Samotraki, N. W. pt.	39	46	19	27
	CORFU, Cape Draste, N. W. pt.	39	48	19	38
	—— Cape Bianco light, S. E. pt.	39	21	20	7
	Paxo light	39	12	20	9
	Leucadia, —— Cape Ducato, S. pt.	38	34	20	33
	CEPHALONIA,				
	—— Cape Viscardo, N. pt.	38	29	20	33
	—— Cape Aterra, N.W.pt.	38	22	20	24
	—— Cape Skala, S. E. pt.	38	3	20	47
	ITHACA, Point Agiani, S. end	38	19	20	46
	Zante, Cape Skinari, N. pt.	37	57	20	42
	—— Cape Kieri, S. pt.	37	39	20	50
	Stamphanes, ——— Convent Island	37	15	21	2
	Cerigo, Cape Spati, N. pt.	36	23	22	57
	—— Kapsali, S. end	36	7	23	0
	Porri	35	58	23	15

Region	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
Candia.	Cerigotto, S. point	35	49 N	23	18 E
	Cape Crio, W. pt.	35	16	23	32
	Cape Spada	35	41	23	44
	Cape Maleka	35	35	24	8
	Cape Retymo	35	25	24	41
	Cape Sassoso	35	25	25	0
	CANDIA	35	21	25	8
	Cape St. John	35	19	25	47
	Cape Sidero, E. end	35	18	26	18
	Cape Salimon, E. end	35	9	26	19
	Gaidronisi Island	34	53	25	43
	Cape Malata	34	55	24	45
	Gozzo Island, W. pt.	34	52	24	2
	Anti Gozzo	34	56	23	39
Grecian Archipelago.	HYDRA, summit	37	20	23	28
	Egina Peak	37	42	23	30
	Zea, port entrance	37	40	24	19
	Thermia, S. point	37	18	24	23
	Andros, Cape Guardia, N. W. pt.	37	58	24	43
	Tinos, St. Nicola Road	37	33	25	8
	Miconi, N. W. mount	37	29	25	21
	Syra, summit	37	29	24	55
	Siphanto	36	58	24	43
	MILO, town	36	42	24	30
	Nio, summit	36	43	25	21
	Naxia, town	37	6	25	22
	Amorga, E. end	36	54	26	6
	Santorin, Mt. St. Elias	36	22	25	29
	Skyros, Mt. Cochila	38	50	24	37
	Scopelo, or Scopoli, ——— Mount Delphi	39	8	23	42
	St. Estrati, summit	39	31	25	2
	LEMNOS, N. W. pt.	39	59	25	3
	—— Cape Stala, S. E. pt.	39	48	25	24
	—— Point Blava, N.E. pt.	40	2	25	28
	TENEDOS, Peak	39	50	26	4
	Samothraki, summit	40	27	25	36
	MYTELEN, Cape Sigri, W. end	39	11	25	50
	—— Port Longoni, ent.	39	5	26	5
	—— Port Oliveir, entrance, S. E. pt.	39	1	26	33
	—— Mytelen	39	6	26	35
	SCIO, —— Cape Mastico, S. end	38	8	25	59
	—— Scio lights	38	22	26	5
	Nicaria, S. W. mount	37	31	26	3
	SAMOS, —— Port Vathi, N. E. end	37	46	27	0
	Patino, or PATMOS, ——— S. mount	37	17	26	35
	Calymnos, summit	37	0	26	59
	Cos, town, N. E. pt.	36	53	27	17
	Scarpanto, S. pt.	35	23	27	10
	——— N. point	35	50	27	11
	RHODES, mole	36	27	28	13
	—— St. Catherine's Island	35	52	27	46
	—— Cape St. John	36	4	28	4
Cyprus.	Cape Salizano, W. pt.	35	6	32	17
	Cape Cormachiti	35	24	32	57
	Cape St. Andrea, N. E. pt.	35	42	34	37
	Cape Grego	34	58	34	6
	Cape Gatte	34	33	33	1
	Baffa, or PAPHOS	34	47	32	26

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

XXXIII. *The Coast of Africa, from Cape Spartel to Cape Verde.*

		Lat.	Long.
		D. M.	D. M.
Morocco.	Cape Spartel	35 48 N	5 54 W
	Araish	35 13	6 10
	Salee	34 03	6 46
	Azamor	33 18	8 15
	Cape Blanco	33 7	8 39
	Cape Cantin	32 33	9 21
	Saffi	32 18	9 12
	MOGADORE ISLAND	31 25	9 32
	Cape Geer	30 38	9 52
	Cleveland Shoal	30 45	10 22
	Santa Cruz	30 30	9 40
	Cape Noon	28 46	11 3
	River Non, entrance	28 17	11 31
	Cape Blanca	27 54	12 42
	False Cape	26 25	14 13
	Cape Bojador	26 9	14 31
	Seven Capes	24 41	15 1
	Cape Barbas	22 19	16 45
	Cape Blanco	20 47	17 4
	Cape Mirik	19 25	16 34
	Portendik	18 20	16 2
	Barbara Point	15 55	16 33
	SENEGAL, Fort St. Louis	16 1	16 32
	CAPE VERDE, —— North-west Pitch	14 44	17 32

XXXIV. *The Western Islands.*

		Lat.	Long.
		D. M.	D. M.
	Corvo, N. pt.	39 44 N	31 07 W
	Flores, N. pt.	39 32	31 12
	Fayal, S. E. point	38 30	28 42
Pico.	Pico, Point de Espertal	38 27	28 36
	—— summit of Peak	38 27	28 28
	St. George, S. E. point	38 31	27 51
	Graciosa, Villa da Praya	39 2	27 59
	Terceira, Angra	38 39	27 12
	St. Michael, P. Delegada	37 45	25 40
	———— Point Ferraria	37 54	25 56
	———— N. E. point	37 50	25 10
	Formigas, or Ants	37 17	24 47
	St. Mary, town	36 59	25 13
	———— W. point	36 59	25 16

XXXV. *Madeira Islands.*

		Lat.	Long.
		D. M.	D. M.
Madeira.	Porto Santo, town	33 4 N	16 19 W
	Madeira, Lorenzo Point	32 43	16 38
	Madeira, Tristram Point	32 54	17 17
	———— FUNCHAL	32 38	16 55
	S. Desertos, S. point	32 28	16 30
	Great Salvage, W. pt.	30 8	15 51
	Piton, Great	30 1	16 0

XXXVI. *Canary Islands.*

		Lat.	Long.
		D. M.	D. M.
	Palma, town	28 39 N	17 56 W
	Palma, N. point	28 52 N	17 55 W
	——— S. point	28 27	17 50
	Ferro, N. point	27 50	17 55
	Gomero, St. Sebastian	28 6	17 8
Teneriffe.	Teneriffe, Hidalgo Point	28 36	16 21
	———— Orotava	28 25	16 32
	———— Tena Point	28 20	17 1
	———— Peak	28 16	16 39
	———— Port Christianos	27 57	16 44
	———— SANTA CRUZ	28 28	16 16
	Canary, N. E. point	28 11	15 25
	——— Palmas mole	28 7	15 25
	——— S. point	27 44	15 34
	Fuerteventura, ——— N. point	28 46	13 54
	——— S. W. point	28 4	14 30
	Lanzarote, S. point	28 51	13 46
	——— Puerto de Naos	28 58	13 34
	——— Punta del Farion	29 14	13 29
	Graciosa	29 14	13 31
	St. Claire	29 17	13 32
	Alegranza	29 25	13 31

XXXVII. *Cape Verde Islands.*

		Lat.	Long.
		D. M.	D. M.
St. Anthony.	St. Anthony, N. W. p.	17 12 N	25 19 W
	——— N. E. point	17 8	25 8
	——— SANTA CRUZ	17 2	25 15
	St. Vincent	16 59	25 6
	St. Lucia	16 46	24 55
	St. Nicholas, N. point	16 42	24 21
	——— E. point	16 34	24 0
	Salt Island	16 45	22 56
	Bonavista, W. pt.	16 2	23 0
	Leton Rock	15 49	23 10
	Isle of May, S. pt.	15 6	23 10
	St. Jago, ——— PORTO PRAYA	14 54	23 30
	——— N. point	15 20	23 47
	Fogo, N. point	15 1	24 22
	—— Peak	14 56	24 21
	Brava, S. point	14 47	24 43

XXXVIII. *From Cape Verde to the Cape of Good Hope.*

		Lat.	Long.
		D. M.	D. M.
Senegambia.	CAPE VERDE	14 44 N	17 33 W
	Goree Island, town	14 40	17 25
	River Gambia, entrance	13 30	16 41
	Cape Roxo	12 20	16 46
	Bissao, fort	11 51	15 37
	Bijooga Islands, — Tombelly, N. point	11 29	15 30
	— Galina Island, W. point	11 28	15 47
	— Orango Island, S. E. pt.	11 3	15 55
	Rio Grande Shoals, ——— South Breakers	10 42	16 18
	Pullam Islands, S. one	10 52	15 45
	Nunez River, entrance	10 36	14 42
	Cape Verga	10 12	14 28
	Delos Islands	9 29	13 48
	Matacong Island	9 14	13 26

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

Region	Place	Lat. D. M.	Long. D. M.
Coast of Guinea.	SIERRA LEONE, Cape.	8 30 N	13 18 W
	—— False Cape	8 26	13 18
	Cape Schilling	8 10	13 10
	Sherbro Island,		
	—— Cape St. Ann	7 34	12 57
	Turtle Islands, N. end	7 41	13 4
	Cape Mount	6 45	11 23
	Cape Mesurado	6 19	10 48
	Sestros River	5 27	9 25
	Cape Palmas	4 22	7 44
	St. Andrew's River	5 0	6 3
	Lahou, town	5 12	4 36
	Cape Apollonia	4 57	2 33
	AXIM	4 55	2 18
	Cape Three Points	4 45	2 4
	Dix Cove, fort	4 48	1 57
	Elmina castle	5 5	1 23
	Cape Coast castle	5 6	1 15
	Anamaboo	5 10	1 7
	Tantumquery Point	5 13	0 47
	Accra	5 32	0 14
	Ningo Fort	5 45	0 2 E
	Cape St. Paul's	5 50	0 58
	Grand Popoe	6 16	1 54
Benin.	Whyda	6 19	2 5
	Lagos, entrance	6 26	3 25
	Benin River, N. pt.	5 46	5 3
	Cape Formosa,	4 15	6 10
	——		
	New Calebar River, W. pt.	4 23	6 55
	Old Calebar River,		
Biafra.	—— Tom Shot's Point	4 35	8 19
	Cameroon River,		
	—— Suellaba Point	3 51	9 35
	Cape St. John	1 10	9 22
Loango.	Gaboon River, S. point	0 22	9 23
	Cape Lopez	0 36 S	8 43
	Settee River, entrance	2 23	9 26
	Loango River, entrance	4 39	11 44
Congo.	River Congo,		
	—— Cape Padron	6 8	12 9
	Ambriz Bay	7 51	13 4
	Dande Point	8 28	13 18
	St. Paul de Loando	8 48	13 13
	Cape Ledo	9 46	13 17
	Nova Redonda	11 12	13 54
	St. Philip de Benguela,		
	—— Fort Flagstaff	12 34	13 25
	Cape Mary	13 26	12 33
Western Coast of Africa.	Little Fish Bay, entrance	15 13	12 7
	Cape Negro	15 42	11 58
	Great Fish Bay,		
	—— Tiger Island, N. pt.	16 30	11 46
	Cape Frio	18 23	12 2
	Cape Cross	21 50	13 57
	Walwich Bay,		
	—— Pelican Point	22 51	14 27
	Angra Pequena	26 38	15 8
	Cape Voltas	28 44	16 32
	Cape Donkin	31 54	18 19
	Cape Deseada	32 15	18 22
	St. Helena Bay,		
	—— Paternoster Point	32 42	17 54
	Saldanha Bay, N. pt.	33 2	17 54

Region	Place	Lat. D. M.	Long. D. M.
Cape of Good Hope.	Point Isser	33 22 S	18 11 E
	Dassen Island	33 26	18 7
	Robben Island	33 47	18 23
	TABLE BAY,		
	—— Cape Town, obs.	33 56	18 29
	—— Green Point light.	33 53	18 25
	Cape of Good Hope	34 22	18 30
	—— Bellows Rock.	34 24	18 30
	FALSE CAPE, or Hang-klip	34 24	18 50

XXXIX. *Islands between Cape Verde, the Cape of Good Hope, and Cape Horn.*

Region	Place	Lat. D. M.	Long. D. M.
	St. Paul's	0 55 N	29 22 W
	Ferdinand Noronha	3 53 S	32 25
	The Roccas, (dangerous,)	3 51	33 49
	Ferdinand de Po, N. pt.	3 47 N	8 43 E
	Prince's Island	1 39	7 27
	St. Thomas, (Man-of-War's Bay,) N. pt.	0 24	6 38
	—— Man-of-War's Bay, S. pt.	0 0	6 30
	Annabona, N. pt.	1 24 S	5 37
	Trinidad, S. pt.	20 31	29 16 W
	Martin Vas, (largest,)	20 29	28 50
	ASCENSION	7 56	14 25
	ST. HELENA, James Town, observatory	15 55	5 45
	Saxemburgh*	30 22	24 00
	Tristan d'Acunha, N. pt.	37 7	12 2
	Inaccessible Islands,	37 16	12 35
	Nightingale Island	37 33	12 20
	Hibernia Rocks, (doubtful,)	37 31	4 42
	Diego Alvarez, (doubtful,)	39 20	11 2
	Gough's Island	40 19	9 44
	——		
	Island Raza, N. W. point	50 59	61 28
	Salvages' Islands, N. point	50 59	61 18
	The Sisters	51 7	60 26
	Port Egmont	51 22	60 1
	Island Concha	51 15	59 00
Falkland Islands.	Cape Leal	51 21	58 57
	Point de la Barra, N.E. point	51 28	57 41
	Cape Corientes	51 24	57 52
	Port Soledad	51 33	58 00
	Cape St. Philip, E. p.	51 43	57 40
	Beauchenes Isl., S. point	52 55	59 12
	Porpus Point	52 28	59 28
	Cape Meredith	52 16	60 39
	Cape Orford	51 56	61 00
	Cape Percival	51 47	61 11
	Aurora Isles,		
	—— northernmost	52 43	48 10
	—— southernmost	53 25	47 59
	Eagle Reef	51 51	64 32
	Alexander's Island	68 51	73 10
	Peter's Island	68 57	90 46
	——		
	Island Georgia,		
	—— Cape Buller	53 58	38 13

* The existence of this island is considered doubtful; though the appearance of land is said to have been seen by several vessels in various situations, from 30° 8′ S. to 30° 45′ S., and from 20° 50′ E. to 28° 20′ E. The island St. Matthew does not exist, being the same as Annabona.

Digitized by Google

TABLE LIV.

Latitudes and Longitudes

		Lat.		Long.	
		D.	M.	D.	M.
Georgia.	Island Georgia,				
	—— Cape Disappointment	54	58 S	36	15 W
	—— Willie's Isle	54	00	38	26
	—— Clerk's Islands	55	1	34	48
Sandwich.	Sandwich Land, Cape Montague	58	27	26	44
	—— Candlemas Isles	57	10	27	13
	—— Southern Thule	59	34	27	45
	Isle of Circumcision	54	16	6	14 E

XL. *The Coast and adjacent Islands from the Cape of Good Hope to Canton.*

		Lat.		Long.	
		D.	M.	D.	M.
Southern Coast of Africa.	CAPE OF GOOD HOPE	34	22 S	18	30 E
	False Cape, or Hangklip	34	24	18	50
	Danger Point	34	42	19	22
	Dyer's Island	34	44	19	28
	Quoin Point	34	49	19	42
	CAPE LAGULLAS l. h.	34	49 8	20	0 7
	Cape Infanta	34	31	20	53
	Cape Vaches	34	20	21	57
	Moselle Bay, —— Cape St. Blaize	34	7	22	12
	Knysna River, E. pt.	34	7	23	8
	Plettenburg Bay, —— Cape Seal	34	5	23	23
	Cape St. Francis	34	10	24	53
	Algoa Bay, commandant's house	33	58	25	40
	—— Cape Recif	34	2	25	41
	—— St. Croix Island, peak	33	48	25	47
	—— Doddington Rock	33	57	26	11
	—— Bird Island, eastern	33	52	26	18
	Point Padrone	33	47	26	25
	Great Fish River, mouth	33	27	27	8
Eastern Coast of Africa.	Keiskama River, entrance	33	17	27	32
	Point Hood, extreme	33	4	27	58
	Buffalo River, —— Cape Morgan	32	42	28	25
	Hole-in-the-Wall	32	3	29	1
	St. John's River, entrance	31	34	29	29
	Cape Natal, extreme	29	53	31	2
	Fisher's River, entrance	29	16	31	33
	Point Durnford	29	0	31	52
	Cape St. Lucia	28	33	32	28
	Cape Vidal	28	10	32	38
	Delagoa Bay,				
	— Cape Collatto	26	4	33	1
	— Cape Inyack	25	58	33	3
	— English River, flag-staff	25	58	32	37
	Inhampura River, entrance	25	12	33	32
	Cape Corrientes	24	8	35	31
	Inhamban Bay, town	23	52	35	25
	Cape Lady Gray	22	56	35	41
	Bazarouta Island, N. pt.	21	31	35	33
	Inverarity's Shoal	20	43	35	10
	Chuluwan Island, N. pt.	20	38	34	54
	Sofala, fort	20	11	34	46
	Quillimane River, town	17	52	37	1
	David's Shoals	17	32	38	32
	Fogo or Fire Island	17	14	38	55
	Raza Island	17	7	39	6
	Macalonga Point	16	59	39	6
	Caldeira Island, centre	16	39	39	46

		Lat.		Long.	
		D.	M.	D.	M.
Eastern Coast of Africa.	Mafamale or Mafamede Isl.	16	21 S	40	4 E
	Mogincale Shoals, middle.	15	35	40	34
	MOZAMBIQUE, St. Jago Island, centre	15	3	40	48
	—— St. George's Isl., fort	15	1	40	47
	Melamo Point	14	25	40	51
	Penda Shoal, E. end	14	15	40	51
	Maunhané, or Devil's Pt.	12	57	40	38
	Querimba Islands,				
	— Querimba Island, N. pt.	12	24	40	39
	— Matemo Island, E. pt.	12	14	40	40
	Vumba Island, E point	11	9	40	43
	Cape Delgado	10	41	40	40
	Lindy River, fort	10	0	39	45
	Keelwa, or Quiloa, —— Pagoda Point	9	2	39	37
	—— Fort.	8	57	39	34
	Monfeea, W. point	7	56	39	38
	Poana Point	7	3	39	37
	Latham's Island, or Sand Bank	6	54	40	1
	Zanzibar Island, S. point	6	28	39	33
	—— N. point	5	43	39	21
	Pemba Island, S. point	5	29	39	42
	Mombas Island, fort	4	4	39	43
	Maleenda Port	3	13	40	11
	Formosa Bay, —— Ras Gomany	3	0	40	19
	Patta, town	2	9	41	7
	Dundas Island, —— Port Durnford, N. p.	1	13	41	54
	Dedalus Shoals	0	24	42	36
	Juba River	0	15	42	39
	Brava, town	1	7 N	44	3
	Torra	1	26	44	21
	Mukdeesha, or Magadosha	2	2	45	25
	Ras Asooad	4	34	48	6
	Ras Awath	5	33	48	40
	Ras Ul Khyle	7	44	49	46
	Ras Mabber	9	29	50	50
	Ras Hafoon, or Orfui	10	28	51	22
	Cape Guardafui	11	50	51	21
	Ras Mett	11	55	50	47
	Mette Island	11	22	48	53
	Burnt Island	11	17	47	21
	Eurburra	10	22	45	6
	Zeyla	11	17	43	0
	Ras Bir	12	17	43	17
	Abdul Koory Island, W. pt.	12	13	52	8
	—— N. E. pt.	12	12	52	23
	Salte's White Rocks	12	26	52	14
	Socotra Island,				
	—— Ras Rarby, W. pt.	12	33	53	18
	—— Tamarin Bay, town	12	37	54	01
	—— Ras Shoorguy, E. pt.	12	34	54	30
Red Sea.	Babelmandel Island	12	38	43	29
	Babelmandel Cape	12	40	43	31
	Panther's Shoal	12	56	43	8
	Cape Ratta	14	56	40	52
	Dhalak Island, D. town	15	46	40	6
	Massowa Bay, lights	15	36	39	21
	Port Mornington	18	16	38	32
	Suakin	19	7	37	20
	Mirza Sheik Baroud	19	35	37	24
	Salaka	20	28	37	27
	Cape Calmez	21	28	37	25
	Cape Ras Elans	23	56	35	48

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat. D.	Lat. M.	Long. D.	Long. M.
Red Sea.	St. John's Island	23	36 N	36	10 E
	Reef of breakers	24	4	36	16
	Three Islands	24	25	35	26
	Reef of breakers	24	54	35	49
	Dedalus Shoal	24	56	35	51
	Centurion Island, doubtful	25	20	35	48
	Koseir	26	8	34	15
	The Brothers	26	21	34	49
	SUEZ	29	59	32	34
	Cape Jehan Peak	28	33	33	20
	Tor Harbor	28	15	33	36
	Ras Mahomed	27	43	34	15
	Shaduan Island, S. point	27	28	34	5
	Bareedy Harbor Cape	24	17	37	33
	Yambo	24	4	38	1
	Juddah	21	29	39	15
	Camfidia	19	7	40	50
	Marabia Reefs,				
	——— Western part	19	11	40	5
	Doorhal Island	16	15	42	8
	Loheia	15	42	42	39
	Cape Israel	15	15	42	41
	Gebel Tor	15	32	42	00
	Gebel Zebayr	15	3	42	13
	Hodeida	14	48	42	54
	Gebel Zeghir, N. I.	14	5	42	44
	Great Arroe	13	41	42	52
	MOCHA	13	20	43	12
Arabian Coast.	Cape St. Anthony	12	41	44	10
	Cape Aden	12	46	45	3
	Cape Bogatshua	14	49	50	3
	Kisseen Point	15	20	51	48
	Cape Fartak	15	38	52	16
	Ras Morebat, extreme	16	58	54	42
	Ras Noss, S. pt.	17	12	55	18
	Curia Muria Isles,				
	——— Jibly Peak	17	29	56	19
	——— Hallanny, N. E. pt.	17	31	56	3
	——— Soda	17	28	55	51
	——— Hasky	17	28	55	35
	Ras Garwow, or Cape Chancilly	17	52	56	21
	Ras Madrake, or Cape Isolette	18	58	57	46
	Massera Island, S. point	20	8	58	33
	——— N. point	20	43	58	52
	Ras Jibsh	21	26	59	12
	Ras al Had, or Cape Rasalgat	22	23	59	55
	Muscat	23	37	58	35
	Burka	23	42	57	57
	Debbah, town	25	36	56	18
Gulf of Persia.	Ormus, fort	27	5	56	29
	La-nek Hill	26	52	56	28
	Kishma Island,				
	——— Kishma, town	26	57	56	19
	——— Luft	26	55	55	55
	Angar or Anguam Island,				
	——— N. point	26	41	55	57
	——— S. point	26	37	55	54
	Great Tumb Island	26	15	55	24
	Bombosa Island	25	54	55	8
	Polior or Belior Isl., middle	26	18	54	35
	Kaez or Kyen Island	26	29	54	2
	Hinderabia	26	40	53	39
	Bushcab, W. point	26	48	53	7

		Lat. D.	Lat. M.	Long. D.	Long. M.
Gulf of Persia.	Crescent Shoal, about	26	44 N	51	43 E
	Cape Budistan	27	58	51	19
	Zezarini Island	27	59	50	8
	Keyn Island	27	45	50	7
	Busheer	29	00	50	50
	Karack Island	29	16	50	19
	BASRA, or BUSSORA	30	30	48	00
	Phelechi Island, S. E. end	29	23	48	19
	Graen	29	23	47	58
	Khubber Island	29	4	48	24
	Garwow Island	28	49	48	42
	Malmaradam Island	28	40	48	35
	Ras-ul-Lur	29	21	48	5
	Ras-ul-Zoor	28	44	48	16
	Durable Shoal	26	57	50	21
	Katif Bay	26	37	50	12
	Kore Hussan	26	4	51	11
	Ras Reccan	26	11	51	17
	Sandy Island	27	52	49	25
	Hawlool	25	40	52	26
	Sherarow	25	2	52	18
	Daeny	24	59	52	25
	Seir Beni Yass	24	18	52	46
	Dalmy, S. end	24	28	52	27
	Arzenie	24	48	52	42
	Jernain	24	56	53	00
	Dauss	25	9	53	1
	Zircooa, or Zara	24	52	53	13
	Seir Abonaid, N. pt.	25	14	54	13
	Ras Luffan	25	55	51	36
	Ras-el-Allarch	25	00	51	39
	Jezurab-ain-Lassart	24	46	51	37
	Ras Boogmais	24	37	51	31
	Goodwin's Islands	24	35	51	43
	Ras-el-Machereeb	24	17	51	45
	Jibbub Hadwareah	24	12	52	47
	Stannu's Shoal, N. end	24	40	53	17
	Mount Jibbul Alli	25	2	55	14
	Abothubbee	24	29	54	32
	Debai	25	17	55	25
	Sharga	25	22	55	29
	Aymaun	25	25	55	33
	Red Island, town	25	43	55	54
	Ras-el-Khyma	25	48	56	4
	Raumps	25	53	56	8
	Shaum, towers	26	2	56	11
	Boukha Point	26	10	56	14
	Cape Jedda or Yedda	26	13	56	16
	Ras Sheik Mumoud	26	16	56	19
	Perforated Rock	26	24	56	28
	Great Quoin	26	30	56	34
	Cape Mussendom	26	24	56	35
	Cape Jask	25	38	57	48
	Churbar	25	19	60	35
	Cape Gwadel	25	4	62	15
	Cape Arubah	25	7	64	30
	Cape Monze	24	51	66	36
	Point Jigat	22	13	69	01
	Diu Head	20	42	70	51
	Scarbett Island	20	56	71	44
	Cambay	22	17	72	36
	SURAT Castle	21	11	72	47
	Vaux's Tomb	21	5	72	38
	Demaun	20	22	73	3
	Omergon	20	11	72	55
	St. John's Highland	20	3	72	43
	Basseen Fort	19	19	72	49

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat. D. M.	Long. D. M.
	BOMBAY (flag-staff,)	18 56 N	72 54 E
	———— light-house	18 54	72 52
	Henery and Kenery Islands	18 42	72 52
	Coullaba Island	18 37	72 54
	Chaoul	18 34	72 54
	Radjapour Harbor	18 16	72 58
	Bancoot River	17 57	73 1
	Sevendroog	17 47	73 5
	Dabul	17 46	73 12
	Argenwell Fort	17 34	73 13
	Boria Point	17 25	73 12
	Zughur Point	17 16	73 10
	Rettna-Geriah	17 2	73 19
	Radjapour Fort	16 47	73 22
	Geriah Point and flag-staff	16 31	73 22
	Angrias Bank, N. p.	16 38	71 43
	———— S. p.	16 18	71 43
	Dewghur Harbor	16 23	73 31
	Atchera River	16 11	73 38
	Melundy, (fortified island,)	16 3	73 39
	Newtee Point	15 56	73 42
	Vingorla Rocks, or Burnt Islands	15 53	73 39
	Raree Point	15 44	73 49
	Chiracole Fort	15 41	73 52
	Chapra Fort	15 36	73 54
	Alguada Pt., N. entrance Goa Bay	15 29	73 46
	GOA	15 28	73 52
	St. George's Isl. (western)	15 22	73 45
	Cape Ramas	15 5	73 55
Malabar.	Oyster Rocks, (outermost,)	14 48	74 03
	Carwar Head	14 47	74 08
	Anjedwa, (island,)	14 44	74 05
	Merjee River	14 30	74 20
	Fortified Island	14 19	74 24
	Onore	14 18	74 27
	Pigeon Island	14 2	74 18
	Barcalore Peak	13 50	74 52
	St Mary's Rocks, N. p.	13 28	74 54
	———— S. p.	13 17	74 54
	Molky Pyramid	13 12	74 51
	Premeira, or Molky Rocks	13 11	74 38
	MANGALORE	12 51	74 49
	Mount Dilly	12 02	75 11
	Canonore Point and fort	11 52	75 21
	Tellicherry flag-staff	11 45	75 28
	Mahe fort	11 41	75 36
	Sacrifice Rock	11 30	75 30
	Calicut	11 15	75 46
	Beypore River	11 10	75 52
	Paniany River	10 47	76
	Chitwa church	10 33	76 03
	Cranganore or Aycotta River	10 12	76 12
	Cochin	9 58	76 14
	Alippee	9 30	76 24
	Porca	9 20	76 27
	Iviker, or Aybicka	8 54	76 35
	Quilon	8 53	76 33
	Angenga fort	8 39	76 45
	Ruttera Point	8 23	76 58
	Cadiapatam Point	8 9	77 20
	CAPE COMORIN	8 5	77 30
	———		
	Ceylon, Point Pedro	9 49	80 23
	——— Columbo	6 57	79 50
	——— Adam's Peak	6 52	80 29

		Lat. D. M.	Long. D. M.
	Ceylon,		
	——— Point de Galle	6 1 N	80 14 E
	——— Matura	5 58	80 36
	——— Dondra Head	5 55	80 38
	——— Grand Bassas	6 11	81 32
	——— Little Bassas	6 25	81 52
	——— Elephant Point, Rk.	6 24	81 32
Ceylon.	——— Agaus, or Aganis	6 53	81 56
	——— Battacola, Fort	7 44	81 42
	——— Vendoos Bay, N. pt.	7 57	81 34
	——— Trincomaley, Flag-staff Point	8 33	81 15
	——— Molewal, or Molateeva House	9 13	80 50
	——— Point Palmyra	9 49	80 14
	———		
	Manapa Point	8 22	78 3
	Trinchindere Pagoda	8 30	78 7
	Punnecoil	8 41	78 6
	Tutacarine	8 48	78 13
	Point Ramen	9 17	79 22
	Deviapatam	9 29	79 00
	Tondy	9 45	79 12
	Point Calymere	10 18	79 51
	——— Pagodas	10 23	79 58
	Negapatam Fort	10 45	79 51
	Five White Pagodas of Nagore	10 49	79 50
	Tranquebar	11 1	79 51
	Devicotta, Coleroon River	11 27	79 47
	Porto Novo	11 31	79 43
	Cuddalore	11 43	79 46
Coromandel Coast.	PONDICHERRY	11 56	79 50
	Sadras	12 32	80 9
	MADRAS, Fort St. George	13 4	80 16
	Ennore	13 15	80 24
	Pulicat	13 25	80 18
	Armegon	13 58	80 2
	Point Pennar	14 30	80 17
	Gondegam	15 20	80 6
	False Point Divy	15 45	81 1
	Point Divy	15 59	81 10
	MASULIPATAM	16 9	81 8
	Narsapour Point	16 19	81 41
	Point Gordeware	16 48	82 27
	Coringa	16 49	82 17
	Jaggernautporam	16 56	82 17
	Wattara	17 26	82 55
	Vizagapatam	17 42	83 17
	Bimlipatam	17 53	83 37
	Chicacole River	18 17	83 54
	Ganjam flag-staff	19 22	85 3
	Manikpatam	19 40	85 39
	Jaggernaut Pagodas	19 48	85 54
	Black Pagoda	19 52	86 8
	False Point	20 20	86 59
	Point Palmyras	20 41	87 11
	BALLASORE	21 30	87 10
	Ingerlee Pagoda	21 44	88 00
	Kedgeree	21 51	87 56
Bengal.	CALCUTTA, Fort William	22 34	88 20
	Chandernager	22 51	88 27
	Sangor I. W. pt.	21 37	88 01
	Light-house Point	21 30	88 27
	Tail Western Brace, S. p.	21 10	87 47
	Tail Western Sea Reef, S. p.	21 00	88 3

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat. D.	Lat. M.	Long. D.	Long. M.
	Tail Eastern Sea Reef, S. p.	20	58 N	88	11 E
	Floating light-vessel	21	2	88	25
Bengal.	Tail of Sauger Sand, S. p.	21	00	88	37
	Codja Deep, (island,)	21	27	88	34
	Islamabad, or Chittagong	22	21	91	48
	Red Crab Island	22	26	91	52
	Dombuck or Elephant Point	21	10	92	4
	St. Martin's Reef, S. pt.	20	34	92	20
	Mosque Point, entrance Aracan	20	7	92	54
	Terribles, W.	19	22	93	16
	Cheduba Pagoda	18	51	93	44
	Tree Island	18	26	93	56
	Foul Island	18	4	94	6
	Church, (or St. John's Rocks,)	17	28	94	23
	Calventura Rocks, N. W.	16	55	94	15
	Buffalo Rocks	16	21	94	12
	Cape Negrais	16	2	94	13
	Diamond Island	15	52	94	17
	Sunken Island, or La Guarda	15	41	94	13
	Rangoon or Pegu River entrance	16	29	96	25
	PEGU	18	00	96	52
	Martaban	16	32	97	35
Pegu.	Tavay Point	13	32	98	9
	Tavay Island	13	6	98	14
	Cabossa Island	12	48	97	55
	West Canister Island	12	42	97	42
	Tanasserim Island	12	34	97	49
	Mergui	12	27	98	36
	Tores Islands, western	11	48	97	26
	Black Rock	11	23	97	38
	Domel Island	11	10	97	57
	St. Matthew's Island	9	58	98	10
	Seyer's Islands, N. p.	8	43	97	40
	——— S. p.	8	28	97	40
	Junkseylon Island, N. p.	8	9	98	18
	——— S. p.	7	46	98	18
	Parlis River	6	21	100	13
	Elephant's Mount	6	10	100	21
	Queda	6	6	100	20
	Prince of Wales's Island, Fort Cornwallis	5	24	100	21
	Cape Caran	3	32	101	8
	Salangore Hill and fort	3	20	101	22
	Pulo Callam or Colong, S. p.	2	56	101	16
	Parcelar Hill	2	52	101	25
	Parcelar Point	2	42	101	32
Malay.	Tanjong Tuan, (Cape Rachado,)	2	26	101	50
	Tanjong Clin, or Peer Punjah	2	17	102	8
	Fisher's Island	2	13	102	12
	Malacca fort	2	11	102	15
	Water Islands, southern	2	4	102	20
	Mount Mora or Moar	1	59	102	40
	Mount Formosa	1	49	102	54
	Mount Battoo Ballo	1	39	103	11
	Pulo Pisang	1	28	103	13
	Pulo Cocob	1	19	103	25
	Sincapore	1	17	103	50
	Little Hill, or False Johore Hill	1	26	104	4

		Lat. D.	Lat. M.	Long. D.	Long. M.
	Johore Hill	1	23 N	104	6 E
	Barbucet Hill	1	25	104	11
	POINT ROMANIA	1	23	104	16
	False Barbucet Hill	1	30	104	16
	Romania Reef	1	25	104	25
	Eastern Bank, (outer part)	1	32	104	35
	Pulo Tingy	2	17	104	11
	Blair's Harbor	2	40	103	40
	Pulo Varela	3	16	103	47
	Pahan Road	3	31		
	Tingoram	4	12	103	18
Malay.	Howard's Shoal	4	14	103	31
	Pulo Brala, or Capas de Mer	4	47	103	41
	Pulo Capas de Terra	5	15	103	12
	Tringany River, entrance	5	21	103	1
	Great Redang Island	5	50	102	56
	Pulo Printian	6	4	102	40
	Calantan Road	6	12	102	14
	Cape Patani	7	4	101	05
	Pulo Lozin	7	18	101	59
	Pulo Cara	8	29	100	35
	Siam River, E. entrance	13	23	100	34
Siam.	JUTHIA, or SIAM	14	55	100	0
	Cape Liant	12	34	101	11
	Pulo Way	9	58	103	48
	Pulo Oby False	8	56	104	38
	Pulo Oby	8	25	104	54
	Cambodia Point	8	35	104	56
	Cambodia River, W. ent.	9	34	106	20
	Cape St. James, (E. entrance Saigon River,)	10	17	107	4
	Cape Trivoane	10	21	107	16
	Point Babeck	10	30	107	33
	Brittos Bank, N. E. p.	10	32	107	48
	Cow Island	10	39	107	52
	Point Kega	10	41	108	4
	Point Vinay	10	54	108	19
	Mui-guio, or Little Cape	11	4	108	31
	Point Lagan	11	9	108	40
	Pulo Ceicer de Terre	11	13	108	48
	Cape Padaran	11	21	109	00
	Padaran Bay	11	35	109	4
	Cape Varela False	11	44	109	12
	Carmaigne Harbor, ent.	11	49	109	12
	Water Islands	12	3	109	19
	Tre Island	12	16	109	19
	Pyramid Island	12	21	109	23
Cochin China.	Nhiatrang	12	26	109	10
	Three Kings Rocks	12	37	109	25
	Hone Cohe Harbor	12	45	109	12
	Cape Varela, or Cape Pagoda	12	55	109	23
	Perforated Rock	12	59	109	23
	Phuyen Harbor, entrance	13	23	109	14
	Coumong Harbor, ent.	13	29	109	13
	Pulo Cambir	13	33	109	18
	Cape Sanho	13	44	109	14
	Quinhone Harbor	13	44	109	11
	Buffalo Island	14	11	109	16
	Point Nuoc Ngol	14	19	109	7
	Tamquan River	14	39	108	56
	Pulo Canton	15	23	109	6
	Port Qui-quick, ent.	15	28	108	50
	Cham Callao	15	59	108	40
	Cape Turon or Tienchu	16	8	108	19
	Callaohanne Island, (N. entrance Turon,)	16	11	108	12

Digitized by Google

TABLE LIV

Latitudes and Longitudes.

		Lat.		Long.	
		D.	M.	D	M.
	Cape Chuvay	16	21 N	107	59 E
	Hue or Huesso River, W. e	16	35	107	41
	Tiger Island	17	10	107	22
Hainan Island.	Hainan Island and adjacent Islands,				
	— Yaitchew Bay	18	24	108	52
	— Yulenken Bay, Zenby	18	11	109	35
	— South Point of Hainan	18	10	109	34
	— Galong Bay	18	12	109	39
	— Brother's Islands, eastern	18	11	109	41
	— Luengsoy Point, S. p.	18	22	110	00
	— Sail Rock	18	26	110	6
	— Saddle Island	18	35	110	11
	— Point of land	18	40	110	24
	— Nankin Island	18	38	110	21
	— Tinhosa Island	18	40	110	28
	— False Tinhosa	18	49	110	34
	— Toongean Mount, pt.	19	35	111	2
	— Hainan Head, N. E. p.	20	00	110	57
	— South Taya Island	19	49	111	12
	— North Taya Island	19	59	111	15
China.	Nowchou centre	20	52	110	36
	Ty-foong-kyoh Island, (Tienpak Harbor,)	21	22	111	13
	Ty-Chook-Chow Island	21	26	111	25
	Song-yue Point	21	31	111	40
	Mamee-Chow, or the Twins, near S. W. p. of Hai-ling-shan	21	34	111	50
	Ty-oa Point	21	43	112	15
	Nampang Island	21	34	112	12
	Mandarin's Cap	21	28	112	22
	Mong-Chow Island	21	39	112	29
	Haw-Cheun, S. W. end	21	35	112	32·5
	Passage Island, (near S. W. p. Haw-Cheun,)	21	35	112	35
	Wy-Caup Island, (near S. point St. John's,)	21	34	112	48
	Lieu-Chew Island	21	36	112	53·5
	Wizard Rocks	21	46	113	02·2
	Ty-kam Island	21	51	113	1
	Cou-cock Island S. W. Pt	21	50	113	08·2
	Tyloo Island, S. p.	21	52·8	113	14
	Great Ladrone	21	56	113	44
	Potoe or Passage Island	22	2	113	39
	Laff-Samee Peak	22	8	113	49
	Typa	22	8	113	33
	Macao, city	22	11·2	113	33
	Lantoa or Tyho Island, S. W. p.	22	12	113	51
	Lintin Island, peak	22	24	113	48
	Asses' Ears	21	53·2	114	02·5
	Great Lema Isl., N. E. p.	22	4	114	19
	Nine Pin Rock	22	16	114	22
	Whampoa anchorage	23	6	113	22
	CANTON	23	7	113	14

XLI. *Islands and Shoals in the INDIAN OCEAN, between the meridians of the Cape of Good Hope and Sumatra, including those W. and N. W. of New Holland.*

		Lat.		Long.	
		D.	M.	D.	M.
Dutch Bank, Stot Van Capelle, various situations,	from	40	00 S	38	50 E
	to..	36	00	43	30
Telamaque Shoal, doubtful, various situations,	from	39	9 S	21	57 E
	to..	38	00	23	24
Brunswick Bank, doubtful		37	25	36	19
French Shoal, doubtful		38	8	43	6
Atlanta's Rock, doubtful		36	43	52	00
Wellington Shoal, very doubtful		39	53	71	43
Prince Edward's Islands,					
——— southernmost		46	53	37	46
——— northernmost		46	40	38	8
Kerguellan's Land, or Isle of Desolation,					
—— Bligh's Cap, N. p.		48	29	68	44
—— Christmas Harbor		48	41	69	4
—— Port Paliser		49	3	69	37
—— Cape Digby, or E. p.		49	23	70	34
—— Cape George, or S. p.		49	54	70	10
—— Island Solitaire		49	49	68	5
—— Cape Louis		49	3	68	18
St. Paul's or Amsterdam Island		37	52	77	35
Amsterdam or St. Paul's Island,		38	46	77	36
Danish Rock, doubtful		28	17	98	25
Cloate's Island, (longitude uncertain,)		22	7	112	30
Tryal Rocks		20	40	105	30
Rosemary Island	Very near New Holland.	20	27	116	30
A reef 10 miles N. W. of Rosemary Island	Very near New Holland.	20	20	116	23
Abrohlos Shoals.	Very near New Holland.	28	30	113	35
Christmas Island		10	31	105	33
Cow Isles,					
——— Northern		11	50	97	4
——— Southern		12	23	97	15
Clark's Reef, S. E. point		17	28	119	20
Imperieuse Shoal		17	35	118	56
Dampier's or Scott's Reef,					
——— N. W. end		13	52	121	59
——— N. E. end.		14	1	122	16
Coral Bank		13	32	124	29
Coral Bank, 9 fathoms		13	25	124	12
Coral Bank, 7 fathoms		12	46	124	32
Cartier's Sandy Island or Bank		12	28	123	56
Red Island, (very near New Holland,)		15	13	124	18
Coral Bank, 10 fathoms or less		12	25	124	11
Hibernia's Shoal		11	56	123	28
Sahul Shoal, S. W. p., 12 fathoms		11	35	124	14
Echo's Soundings, Rock		11	16	126	00
Coral 7 fathoms Bank		9	56	129	35
Fortune Shoal		33	8	43	5
Union Shoal		35	25	41	12
Dutch Bank		31	44	44	00
Otter's Shoal, doubtful		33	56	36	00
Princess Augusta's Shoal, doubtful		33	44	36	16
Union Rocks, doubtful		35	23	41	20
Swallow Rocks and Breakers, doubtful		28	20	42	10
Belliquese Shoal, doubtful		28	43	42	33

TABLE LIV.

Latitudes and Longitudes.

		Lat. D. M.	Long. D. M.
West Coast of Madagascar.	CAPE ST. MARY......	25 39 S	45 7 E
	Star Reefs, S. end	25 24	44 18
	St. Augustine Bay, ——— Sandy Island	23 38	43 38
	Cape St. Vincent	21 54	43 20
	Mourondava	20 18	44 19
	Cape St. Andrew........	16 11	44 31
	Boyanna Bay, entrance...	15 59	45 23
	Bembatooka Bay, ——— Majunga Point	15 43	46 20
	Majambo Bay, entrance ..	15 12	46 59
	Nareenda Bay...........	14 40	47 26
	Sancasse Island, N. pt....	14 31	47 35
	Passandava Bay, ——— Nine Pin Island	13 28	48 15
	Dalrymple Bay..........	13 30	48 2
	Nos Beh Island, N. pt. ...	13 12	48 19
East Coast of Madagascar.	Minow Island, N. pt......	12 50	48 39
	Cape St. Sebastian	12 26	48 46
	CAPE AMBER, N. E. pt.	11 58	49 19
	British Sound, entrance ..	12 14	49 23
	Port Leven, ——— Nosh How Island	12 48	49 53
	Cape East, town.........	15 14	50 30
	Antongil Bay, Port Choiseul	15 27	49 52
	——— Cape Bellones	16 14	49 54
	St. Mary's Island, N. pt...	16 41	50 5
	——— S. pt...	17 7	49 51
	Foul Point.............	17 40	49 37
	Tamatave Point	18 10	49 28
	Fong Isles	18 27	49 26
	Manooroo..............	19 55	48 52
	Rangazarah	20 58	48 33
	Manambatoo	24 17	47 25
	St. Luce Bay, N. Isle	24 45	47 14
Comoro Is.	FORT DAUPHIN......	25 1	47 2
	Star Bank .... {	25 7 25 25	44 16
	Bassas de India..........	22 23	40 24
	Europa Rocks, S. pt.	21 31	39 36
	Sussex Rocks	21 25	42 36
	Bazaruto Islands, Cape...	21 31	35 33
	Barren Islands, western ..	18 41	44 3
	English Bank	17 40	40 15
	Juan de Nova or St. Christopher's Island	17 3	42 47
	Coffin Island...........	17 30	43 47
	Chesterfield Shoal	16 17	43 55
	Mayotta Island..........	12 54	45 14
	Mohilla Island, E. pt.	12 20	44 0
	Johanna Island, peak	12 15	44 30
	Comoro, S. E. pt.	11 54	43 33
	Portuguese Shoals	12 30	46 50
	John Martin's Island, doubtful	10 15	43 50
	Rover Shoal	12 22	46 25
	Aldabra Islands, N. W. p..	9 23	45 50
	Assumption Island, Hum'k	9 46	46 34
	Cosmoledo Island, N. pt. .	9 38	47 36
	Marquis of Huntley's Bank	9 55	50 15
	St. Peter's Island........	9 20	50 50
	Natal Island, doubtful	8 26	47 12
	Sandy Island...........	9 10	48 10
	St. Lawrence Island	9 37	50 23
	Zanzibar Island, S. p.....	6 28	39 33
	——— N. p.....	5 43	39 21
	Amirante Island, N. W. p	5 10	53 45
	——— S. E. p..	6 20	54 30

		Lat. D. M.	Long. D. M.
Mahe Bank.	Mahe Bank, N. W. p.....	3 20 S	54 40 E
	——— S. E. p.....	5 30	56 59
	——— Seychelle or Mahe Island	4 37	55 31
	——W. pt. Praslin Island	4 17	55 44
	French Shoal...........	3 58	54 42
	African Islands..........	4 55	53 30
	Alphonso Island.........	7 0	52 43
	Sandy Island or Bank....	7 12	52 43
	Isle Bourbon St. Denis...	20 52	55 29
	Mauritius, or Isle of France, ——— Port Louis	20 10	57 30
	Diego Rais or Rodrique ..	19 40	63 24
	St. Branden or Cargados Garajos, —— N. part of the Bank	13 41	61 15
	—— Low Sandy Island .	16 5	59 47
	—— Islet with huts.....	16 27	59 40
	—— South Islet........	16 47	59 34
	Nazareth Bank, S. W. p. .	16 47	59 31
	——— N. E. p...	13 41	61 15
	Sandy Island............	15 52	55 34
	Galega, or S. Roquepiz, middle	10 25	56 39
	Saya de Malha Bank... { ——— limits... {	11 30 8 18	62 20 59 58
	Fortune Bank, 10 fath. ...	7 16	57 0
	John de Nova, N. pt.	10 7	51 8
	Providence Island, N. pt. .	9 9	51 7
	Coetivy Island, N. pt.	7 6	56 22
Chagos Archipelago.	Chagos Archipelago,		
	—— Diego Garcia ..... {	7 29 7 14	72 22
	—— Pitt's Bank....... {	7 17 6 50	71 18
	—— Centurion's Bank...	7 37	70 57
	—— Ganges Bank.......	7 22	71 2
	—— Owen's Bank.......	6 46	70 20
	—— Egmont's or Six Islands.............	6 37	71 24
	—— Danger Island......	6 29	71 13
	—— Eagle Island........	6 10	71 18
	—— Three Brothers	6 9	71 35
	—— Peros, Banhos Islands	5 22	71 48
	—— Saloman's Isl's, S. W.	5 22	72 10
	—— Sandy Islands	5 17	72 37
	—— Speaker's B'k, N.E.pt.	4 45	72 24
	Pona Molubque Atoll, S. p.	0 41	73 6
	——— N. W. p.	0 34	73 12
	——— N. E. p..	0 33	73 25
	Addon Island, middle....	0 21	73 35
	Suadiva, southern group, ——— South Reef....	0 9 N	73 15
	——— South Island....	0 11	73 12
	——— S. W. Island....	0 18	73 4
Maldivia Archipelago.	——— N. W. Island....	0 28	73 2
	——— N. Island.	0 34	73 8
	——— Northern group, S. W. Island .	0 48	73 19
	——— N. W. Island....	0 51	73 20
	——— N. E. Island	0 58	73 33
	Adoumatis Atoll,		
	—— S. W. extremity....	1 50	73 27
	—— Southernmost Island	1 47	73 22
	—— Island	1 51	73 38
	—— N. W. Island.......	2 7	73 35
	—— N. E. Island.......	2 7	73 35

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
Maldivia Archipelago.	Collomandous Atoll, — South Island	2	13 N	73	21 E
	— Long Island	2	21	73	8
	— N. W. extremity	2	30	73	8
	— West entrance of Coll. Channel	2	10	73	21
	Molucque Atoll, S. ex.	2	46	73	23
	Nillandos Atoll	2	40	72	54
	Poulisdous Atoll	3	36	73	44
	Ari Atoll, N, Is. S. pt.	3	30	72	50
	Male Atoll, or Maldivia, S. E. p.	4	27	73	42
	Gafer Island	4	46	73	40
	Todu Island	4	26	72	58
	Cordivia Island	4	58	73	26
	Maloss Madoll, S. pt.	5	00	72	58
	Padipolo Atoll, E. p.	5	25	73	38
	Milla Doue Atolls, E. pt.	5	51	73	27
	Tilla Dou Matis, or Head of the Islands, northern limit	7	6	72	53
	Minicoy, or Malicoy	8	17	73	3
	Seuvelli Islands, — Southern	10	0	72	12
	— Northern	10	5	72	15
	— Southern extreme Reef.	9	56	72	9
Laccadive Archipelago.	Kalpeni Islands, S. p.	10	4	73	35
	— N. p.	10	10	73	35
	Courutee Island	10	31	72	36
	Pittie Sand Bank	10	45	72	32
	Underoot Island, E. pt.	10	48	73	42
	Aucutta Island	10	51	72	10
	Bingaro Island	10	55	72	16
	Tingaro Island	10	55	72	18
	Ameni Island	11	6	72	41
	Permulpar Island	11	9	72	0
	Cardamum Island,	11	14	72	44
	Elicapeni Bank, E. pt.	11	13	73	56
	Kittan Island, S. pt.	11	25	73	0
	Betrapar Island, N. ex.	11	35	72	11
	Chittae Island	11	40	72	42
	Cherbaniano Bank, (not explored,) S. pt.	12	15	72	0
	Angrias Bank, N. p.	16	38	71	43
	— S. p.	16	18	71	43
	Bale of Cotton Rock, (doubtful,)	5	18	88	20
	Le Meme's Reef,(doubtful)	1	20	94	20
Andaman Islands.	Preparis Island, N. p.	14	56	93	40
	— S. p.	14	49	93	40
	Great Coco Island, N. p.	14	11	93	21
	— S. p.	14	2	93	21
	Little Coco Island	13	58	93	15
	Landfall Island	13	39	93	4
	Great Andaman, — Cape Price, N. end	13	34	93	4
	— S. E. point	11	30	92	56
	— Port Cornwallis	13	20	93	7
	— Port Chatham	11	43	92	47
	— Port Campbell	11	56	92	39
	Rutland Island, S. p.	11	24	92	47
	Interview Island, N. p.	13	1	92	46
	— S. p.	12	47	92	41
	North Centinel	11	33	92	22

	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
	South or Little Centinel	11	00 N	92	22 E
	Five Islands, S. p.	11	17	92	55
	Sisters, southern	11	10	92	46
	Brothers, northern	11	00	92	41
	Little Andaman, N. p.	10	53	92	38
	— S. E. p.	10	26	92	40
	Invisible Bank, N. p.	11	27	93	41
	— S. p.	10	56	93	40
	— Flat Rock	11	8	93	34
	Barren Island	12	16	93	54
	Naroondam	13	26	94	18
Nicobar Islands.	Car Nicobar	9	10	92	46
	Batty Maloe	8	46	92	51
	Chowry Island	8	28	93	3
	Terressa Island, N. p.	8	22	93	17
	— S. p.	8	12	93	6
	Katchall, W. end	7	54	93	23
	Noncowry Island and harbor	8	00	93	46
	Comorta, N. p.	8	15	93	42
	Tillangchong Islands, N. p.	8	33	93	40
	— S. p.	8	22	93	40
	Meroe Island	7	29	93	34
	Little Nicobar, N. p.	7	26	93	42
	— S. p.	7	13	93	34
	Great Nicobar, N. p.	7	8	93	55
	— S. p.	6	45	93	54

XLII. *The Islands of Sumatra, Java, Billington, Gaspar, Banca, with the adjacent Islands and Straits.*

	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
Sumatra.	Acheen	5	35 N	95	19 E
	Golden Mountain	5	22	95	45
	Pedir Point	5	29	96	5
	Elephant Mountain	5	3	96	50
	Tooloo-Samwoi Point	5	13	97	14
	Diamond Point	5	14	97	38
	Tanjong Bou	1	5 S	104	30
	Batacarang Point	2	0	104	51
	Fourth Point	2	20	105	15
	Third Point	2	23	105	32
	Second Point	2	41	105	41
	First Point	3	00	106	3
	Hog Point	5	54	105	45
	Flat Point	6	00	104	36
	Billimbing Bay	5	54		
	Bencoonat	5	35	104	27
	Cawoor	4	56	103	34
	Manna Point	4	33	102	49
	Buffalo Point	3	58	102	19
	BENCOOLEN, (Fort Marlborough,)	3	48	102	19
	Caytone	3	29	102	14
	Moco-Moco	2	34	101	20
	Indrapour Point	2	10	100	48
	Padang Head	0	56	100	20
	Priaman	0	40	100	10
	Natal	0	33 N	99	0
	Tappanooly, P. Kasheel	1	44	98	45
	Tappoose	2	00	97	57
	Sinkel Point	2	15	97	46
	Bulo Samah	2	33	97	54

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat.		Long.	
		D.	M.	D.	M.
Sumatra.	Troumon	2	49 N	97	51 E
	Pulo Duas	2	54	97	44
	Baccoongung	2	57	97	42
	Pulo Munkie	2	55	97	39
	Oujong Coomoowung	2	57	97	38
	Oujong Cluet	3	4	97	32
	Qualah Bahoo	3	6	97	31
	Qualah Assehahn	3	8	97	30
	Tampat Tuan	3	16	97	23
	Batto Plyeer	3	20	97	19
	South Tallapou	3	22	97	18
	Pulo Sooroodung	3	25	97	16
	Muckie	3	28	97	14
	Laboun Hadjie	3	34	97	11
	Mungin	3	38	97	4
	North Tallapou	3	39	97	3
	Soosoo	3	44	96	58
	Pulo Kio	3	44	96	57
	Qualah Battoo	3	45	96	56
	Oujong Se Mium	3	45	96	46
	Cape Felix	3	44	96	42
	Oujong Tripah	3	54	96	31
	Senahgun	4	4	96	24
	Analaboo	4	7	96	18
	Oryong-Booboon or Bahoo	4	13	96	5
	Pulo Rungass, off Rigas Bay	4	38	95	38
	Oujong Chellung	4	38	95	40
	Rigas	4	39	95	40
	Tellow Goolumpung	4	42	95	37
	Pulo Cass	4	46	95	34
	Pulo Riah and Pulo M. centre	4	52	95	30
	Barbee Wee	4	55	95	30
	Diah	5	2	95	28
	Oujong Dahway	5	5	95	25
Islands W. of Sumatra.	Pulo Rondo	6	4	95	14
	Pulo Way	5	49	95	23
	Pulo Brasse	5	42	95	6
	Pulo Rajah	4	40		
	Cocos Islands from	2	59	95	33
	Cocos Islands to	3	2	95	33
	Hog Island, N. p.	2	57	95	58
	——— S. p.	2	21	96	38
	Pulo Assayo	2	41	96	34
	Coral Bank	3	31	96	42
	Flat Islands from	2	4	96	47
	Flat Islands to	2	13	96	54
	Burgh Rock	2	47	97	26
	Shoal, 10 feet	2	48	97	33
	Castlereagh Shoal	3	5	97	6
	North Pulo Dua	2	52	97	39
	Passage Island	2	25	97	50
	Bird Island	1	56		
	Pulo Lucotta	1	50	98	7
	Londise Shoal, (N. N. E. ½ E. from Lucotta, distant 2½ leagues,)	1	57		
	Mensular Island, N.W. pt.	1	40	98	30
	Pulo Dua	1	27	98	20
	Pulo Nyas, S. p.	0	36	97	56
	Pulo Tamong	0	24	98	40
	Pulo Panjang	0	13	98	30
	Clappe s Island, middle	0	0 S	98	30
	Pulo Mintaon, or Batao	0	25	98	7
	Pulo Ayer Besar	1	24	100	17

		Lat.		Long.	
		D.	M.	D.	M.
Islands W. of Sumatra.	Se-beero, or G. Fortune Island, N. p.	0	56 S	98	38 E
	——— S. W. p.	1	47	99	2
	Se-pora, or South Pora, N. W. p.	2	00	99	33
	— S. p.	2	25	99	58
	North Poggy Island, N. p.	2	32	99	37
	——— S. p.	2	52	100	13
	South Poggy Island, N. p.	2	50	100	15
	——— S. p.	3	20	100	41
	Laage or Larg Islands	3	30	101	3
	Rat Island	3	51	102	15
	Trieste or Reefs Island	4	3	101	6
	Pulo Pisang	5	8	104	6
	Little Fortune Island	5	54	104	30
	Engano or Deceit Island, N. p.	5	15	102	25
	— E. point	5	22	102	40
	— S. E. point	5	30	102	38
	— S. point	5	31	102	20
	— W. point	5	21	102	10
Java.	Java Head	6	48	105	13
	First Point	6	44	105	12
	Second Point	6	36	105	21
	Third Point	6	27	105	40
	Anger	6	3	105	56
	Bantam or St. Nicholas Point	5	53	106	4
	Bantam	6	2	106	10
	BATAVIA obs.	6	8	106	50
	Carawang Point	5	57	107	3
	Sedary Point	5	54	107	27
	Point Pamanoekan	6	11	107	49
	Woerden Castle Rock	5	58	107	58
	Princess Charlotte Shoal	5	58	107	54
	Indramaye Point	6	12	108	20
	Pulo Rackit	5	56	108	22
	Bumkin's Island, or outer Shoal	5	47	108	23
	Cheribon Mountain	6	55	108	26
	Taggal	6	50	104	14
	——— Rock	6	46		
	Samarang flagstaff	6	57	110	27
	——— anchorage	6	53	110	26
	Mandalique Island	6	22	110	51
	Lerang Point	6	35	111	27
	Rambang	6	41	111	17
	Point Panka or Panco	6	53	112	32
	Sourabaye, fort	7	15	112	45
	Cape Sandana	7	49	114	22
	Balambonang Bay, Pt. Goonog Ikan	8	23	114	25
	——— E. point	8	46	114	33
	Turtle Bay	7	48	109	48
	Tulan or Dirck Vrie's Bay	7	50	108	12
	Wine Cooper's Point	7	25	106	26
	Noesa Baron Island, S. p.	8	32	113	18
	Tangala Islands, largest	8	26	112	26
	Clappe's Island, about	7	1	105	29
	Mew Island	6	43	105	15
	Peak on Prince's Island	6	35	105	15
	Peak on Crocatoo Island	6	8	105	29
	Peak on Tamarind Island, or Pulo Bessy	5	56	105	28
	Pulo Sebooko	5	53	105	34

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat. D.	Lat. M.	Long. D.	Long. M.
	Cap	5	59 S	105	57 E
	Button	5	53	105	57
	Thwart-the-way	5	57	105	51
	Zutphen Islands,(largest,) N. p..	5	50	105	47
	South Watcher	5	41	106	43
	Man-eater's Island	5	54	106	30
St. of Sunda.	Pulo Baby	5	48	106	14
	Thousand Islands, N.	5	32	106	35
	Pruysen's Droogte Shoal	5	17	106	47
	Armuyden Bank	5	13	106	48
	North Watcher	5	12	106	30
	Three Sisters	5	44	105	48
	North Island	5	41	105	49
	Two Brothers, northern	5	9	106	3
	Lynn Shoal	5	12	106	13
Banca St.	Shabunder Shoal	5	9	105	56
	Brouwer's Shoal	5	5	106	14
	Lucepera, S. entrance St. Banca	3	13	106	8
	Nanka Islands	2	25	105	48
	Banca Island,				
	—— South Point	3	8	106	28
	—— Tanjong Panjong, or Point Lalary	2	49	106	4
	—— Monopin Hill	2	00	105	12
	—— Tanjong Goonting	1	43	105	20
	—— Tanjong Muncooda, N. of Banca	1	28	105	53
	—— Tanjong Tuan	1	38	106	6
Banca Island.	—— Songy Leat Bay	1	50	106	9
	—— Tanjong Ryah	1	55	106	14
	—— Goonong Marass Mount	1	53	105	52
	—— Tanjong Breket	2	36	106	50
	—— Rocky Point	2	56	106	54
	—— Entrance Point, or S. E p.	3	2	106	52
	Essex Shoal, or Fairlie Rock	3	27	107	2
	Vansittart's Shoals {	3	11	107	2
		3	5	107	8
	Pulo Leat or Middle Isl.	2	51	107	5
	Alceste Shoal	2	46	107	2
	Shoal Water Island	3	20	107	13
	South Island	3	00	107	15
	North Island	2	58	107	15
	General Hewitt's Rock	2	53	107	14
	Discovery Rock	2	54	106	56
	Pulo Glassa or Gaspar Isl.	2	25	107	4
	Tree Island	2	28	106	58
	Warren Hastings's Shoal	2	23	106	57
	Belvidere's Shoal, N. pt.	2	11	107	00
Gaspar St.	Vansittart's Shoal	2	11	106	42
	Hillsborough Shoal	2	3	106	22
	Magdalen's Shoal	1	56	107	0
	Severn's Shoal	1	40	106	30
	Billiton Island, S. E. p.	3	22	108	10
	———— S. W. point	3	15	107	31
	———— N. p.	2	33	107	53
	N. W. Island, off Billiton	2	31	107	33
	Shoe Island, (formerly Bird Island and White R.)	3	47	108	0
	Fox Shoal	3	30	110	6
	Pulo Mancap	3	5	110	7
	———— Shoal, S p.	3	22	110	7

		Lat. D.	Lat. M.	Long. D.	Long. M.
	Discovery's Western Bank	3	39 S	108	43 E
	———— Eastern Bank	3	33	109	10
	———— Reef	3	36	108	48
	Osterly's North Shoal	3	19	108	40
	Cirencester's Sand Bank	3	17	109	0
	———— Shoal	2	54	108	58
	Montaran Islands, South	2	35		
	—— Eastern	2	31	108	52
	—— Toekoekemou, (highest island,)	2	31	108	36
	Minto Rocks	2	14	109	51
	Ontario's Shoal	2	1	108	39
	Rendezvous Island, S.W.p	2	44	110	9
	Souroutou, W. p.	1	42	108	38
	Carimata Island Peak	1	36	108	51
Billiton St.	Pulo Papan	1	28	109	26
	Pulo Panumbangan	1	12	109	12
	Massa Teega Isles	0	55	109	18
	Greig's Shoal	0	55	108	35
	The Seven Islands, N. W.	1	8	105	12
	Pulo Varela or Barallah	0	50	104	25
	Pulo Taya	0	45	104	55
	The Calantigas	0	35	103	51
	Ilchister Shoal	0	26	104	57
	Lingin, Tanjong Eang, S. E. extremity	0	20	105	0
	East Domino Island	0	10	105	0
	Geldrias Bank, same as Dogger Bank	0	48 N	104	58
	Rhio	0	57	104	30
	Eastern Island, off Pulo Panjang	1	01	104	49
	Island Laage, E. pt.	0	46	104	45
	Three Brothers, south	0	31	103	44
	Pedro Branco	1	20	104	23
	Islands off P. Romaine	1	23	104	16
	Bintang Island, (the hill,)	1	2	104	26
	———— N. W. p.	1	10	104	16
	Johore Shoal	1	18	104	4
	Shoal ent. Rhio Straits	1	8	104	11
	Sincapore Island, E. p.	1	22	104	00
	Pulo Battain, N. E. p.	1	10	104	4
	St. John's Island, S. p.	1	14	103	51
	Rocky Reefs	1	9	103	55
	Middle Island	1	13	103	46
	Coney Island	1	9	103	41
	Buffalo Rock	1	9	103	48
	Rocks	1	6	103	45
	Red Island	1	6	103	38
	Tree Island	1	8	103	36
	Alligator Island	1	10	103	40
	Rocks	1	12	103	36
	Little Carimon	1	8	103	22
Sincapore St.	Great Carimon, S. pk.	1	5	103	19
	The Brothers	1	10	103	21
	Pulo Cocob	1	19 S	103	25
	Pulo Pisang	1	28	103	13
	Water Islands, or Four Brothers, S. p.	2	4	102	20
	Fisher's Island	2	13	102	12
	Bambeck Shoal	2	37	101	41
	Pulo Callam or Colong, S. p.	2	56	101	16
	Two and a half fathoms Bank	2	54	101	4
	Round Arroa	2	49	100	35
	Blenheim's Shoal	3	3	101	2

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat. D. M.	Long. D. M.
Malacca St.	Long or Great Arroa....	2 52 N	100 44 E
	Two Brothers, Pulo Pandan	3 24	99 54
	——— Pulo Salanama	3 21	99 52
	Pulo Varela............	3 47	99 36
	Pulo Jarra	4 00	100 10
	Sambilang Isl., southern.	4 3	100 30
	Dinding Island, W. p....	4 16	100 35
	Prince of Wales's Island, Fort Cornwallis	5 24	100 21
	Pulo Pera............	5 42	98 57
	Boonting Island, southern	5 45	100 18
	Pulo Bonton, (dome,)....	6 33	99 17
	Pulo Ladda, S. p........	6 8	99 42
	Trotto Island, N. p......	6 49	99 39
	Sangald or Guilder Rock	7 10	98 45
	Pulo Telibon, S. W.	7 30	99 24
	The Brothers...........	7 31	98 20
	Pulo Rajah, or P. Taya..	7 36	98 18
	Junkseylon, S. p........	7 46	98 18

XLIII. *Islands and Shoals in the CHINA SEA.*

		Lat. D. M.	Long. D. M.
Tambelan Islands.	St Barbe Island	0 7 N	107 13 E
	Direction Island	0 15	108 2
	Pulo Datoo	0 7	108 32
	Welstead's Rock	0 32	107 53
	St. Esprit Islands, E.....	0 34	107 13
	Green Island..........	0 40	107 30
	St. Julian Island........	0 54	106 46
	Tambelan Islands, East or Great Island	1 00	107 35
	Gap Rock.............	1 12	107 35
	Europe Shoal	1 12	107 26
	Rocky Island	1 9	107 14
	Camel's Hump	1 10	106 55
	Saddle Island	1 16	107 1
	French White Rock	1 32	106 32
	Victory Island	1 34	106 20
	Acasta Rock	1 39	106 19
	White Rock	2 18	105 33
	Macedonian Reef.......	2 25	105 32
Anambas Islands.	South Anambas, limits {	2 18	106 8
		2 40	106 30
	Pulo Domar...........	2 45	105 21
	Middle or G. Anambas, W. limit............	3 9	105 41
	North Anambas	3 27	106 15
	Pulo Tingy	2 17	104 11
	Ex. Islet off P. Tingy....	2 8	104 14
	Pulo AOR or Wawoor ..	2 29	104 35
	Pulo Pisang or Pambeelan.................	2 37	104 13
	Pulo Timoan, S. p.	2 44	104 15
	— N. p.	2 54	104 15
	— Bay on S. W. side ...	2 48	
	— N. Islet off N.W. side..	2 56	
	Pulo Varela	3 16	103 47
	Pulo Brala, or Capas de Terre................	4 47	103 41
	Pulo Capas de Terre	5 15	103 12
	St. Pierre Islands.......	1 54	108 41
	—— Ledge of Rocks....	1 53	108 52
	Larkin's Reef	2 11	109 16

		Lat. D. M.	Long. D. M.
Natunas Islands.	South Haycock Island ..	2 9 N	109 10 E
	South Natunas Islands,		
	— South Island, or Sapata	2 26	109 8
	— East Island..........	2 42	109 18
	— West Island.........	2 50	108 28
	— North or Flat Island..	3 3	108 54
	Low Island	3 0	107 45
	Hutton's Shoal.........	3 0	107 57
	Diana Shoal...........	3 9	107 44
	North Haycock Island...	3 15	107 18
	Grand or Great Natuna {	3 40	108 26
	Island, limits ...... }	4 16	108 11
	——— Mt. Peaked Island	4 01	108 10
	Pyramidal Rocks	4 7	107 26
	—— N. W. Island......	4 7	107 50
	—— Coral Reef	4 1	107 50
	—— Coral Reef	3 57	107 47
	North Natunas Islands, S.p.	4 42	107 58
	—— N. p............	4 51	108 0
	—— Rock above water..	4 39	107 57
	—— Saddle Island......	4 31	107 44
	—— Success Shoal......	4 23	107 54
	Pulo Oby..............	8 25	104 54
	The Brothers, (eastern,).	8 35	106 15
	Pulo CONDORE........	8 40	106 42
	Charlotte's Bank	7 5	107 37
	Phaeton Bank..........	7 0	107 29
	Royal Bishop's Bank, S.p.	9 40	108 21
	Britto's Bank	10 32	107 48
	Holland's Bank, S. W. p.	10 36	108 32
	——— N. E. p.	10 48	108 47
	Pulo SAPATA.........	10 1	109 2
	Pyramid Rock, or Little Catwick	10 2	109 00
	Round Island, or Great Catwick	10 6	108 52
	Pulo Ceicer de Mer.....	10 32	108 53
	Minerva's Bank	10 37	110 18
Paracels.	Investigator's Coral Patch	14 12	112 52
	Triton's Island or Bank, S. W. part.........	15 45	111 11
	Passoo Keah, (Sandy Isl.)	16 3	111 45
	Bombay Merchant's Shoal, ——— E. p.	16 4	112 38
	——— S. p.	15 59	112 26
	Discovery Shoal, W. p...	16 11	111 32
	——— E. p...	16 16	111 46
	Jehangire's Coral Bank..	16 18	112 35
	Vulador's Shoal, E. p....	16 19	112 7
	——— W. p...	16 18	112 0
	Crescent Chain,		
	—— Money's Island....	16 28	111 30
	—— Robert's Island	16 31	111 34
	—— Pattle's Island.....	16 33	111 36
	—— Drummond's Island	16 29	111 44
	—— Governor Duncan's Island	16 27	111 40
	—— Antelope's Shoal...	16 27	111 35
	Observation Bank, N. p..	16 37	111 41
	Pyramid Rock..........	16 35	112 37
	Lincoln Island..........	16 40	112 42
	Rocky Island..........	16 52	112 20
	Woody Island..........	16 50	112 18
	Amphitrite Islands, W. p.	16 59	112 12
	——— E. p.	16 54	112 23
	North Shoal, W p.......	17 5	111 26
	——— E. p...	17 6	111 32

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

Region	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
	Macclesfield Bank, limits	15	17 N	113	44 E
		16	21	114	59
	Scarborough or Marsingola Shoal, limits	15	4	117	44
		15	13	117	53
	St. Esprit Shoal, (by Lt. Ross,)	19	30	113	6
	———— (by Asseveido,)	19	6	113	5
Pratas.	Pratas or Prater's Shoal,				
Pratas.	———— N. E. p.	20	47	116	54
Pratas.	———— N. W. p.	20	45	116	42
Pratas.	———— Anchorage	20	43	116	42
Pratas.	———— Island	20	43	116	45
	Great Ladrone	21	57	113	44
	[The Islands near Canton are given in No. XL. and in No. XLVI.]				
	Pedro Branco	22	19	115	8
	Lamock Islands, outermost	23	14	117	19
	———				
	Andrade Rock, (very doubtful,)	9	56	111	4
	Luconias Shoals,				
	—— Hard Rocks	5	24	112	30
	—— Two Fathom Shoal	5	5	112	24
	—— Dry Sand	4	57	112	30
	Sea-Horse Reef	5	35	112	28
	—— Half-Moon Breakers	8	46	116	30
	—— Bank	10	57	117	53
	Paraquas, 5 or 6 leagues from Palawan	9	10	117	28
	Euphrates Shoal	5	42	113	30
	Kirton's Shoals	5	39	113	15
		5	49	113	2
	Louisa's Breakers	6	20	113	18
	Mantannane Isles	6	39	116	7
S. . . art . hina Sea.	Barton's Shoals	6	52	116	13
S. . . art . hina Sea.	Royal Charlotte's Rocks	6	57	113	38
S. . . art . hina Sea.	———— Sands	10	47	114	29
S. . . art . hina Sea.	Swallow or Investigator's Rocks	7	23	113	49
S. . . art . hina Sea.	Viper's Bank	7	30	115	0
S. . . art . hina Sea.	——— Breakers	8	00	115	25
S. . . art . hina Sea.	Ardasier's large coral flats and gaps,				
S. . . art . hina Sea.	— W. p. (Walpole, Cornwallis and A)	7	56	113	12
S. . . art . hina Sea.	— N. E. p. (Walpole and A.)	7	54	114	24
	— E. p. (Ardasier)	7	40	114	47
	— S. p. (Pennsylvania and A.)	7	30	114	34
	Gloucester Shoal	7	50	114	14
	Stag's Shoal	8	24	112	57
	Prince of Wales's Bank, limits	8	5	110	27
		8	13	110	34
	London Breakers	9	36	112	26
	—— Reef, western	8	55	112	00
	—— Reef, eastern	8	48	112	24
	—— Breakers	7	33	113	14
	—— Breakers	7	25	113	3
	Ganges Breakers	9	25	114	10
		10	30	115	10
	Investigator's Shoal, W.p.	8	5	114	35

Region	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
	Investigator's Shoal, E. p.	8	10 N	114	51 E
	—— Shoal	9	12	116	32
	—— Shoal	10	44	114	34
	—— Coral Rocks	9	40	113	4
		9	42	113	15
	Cavallo Marino's Shoal	5	54	114	18
		8	31	114	21
	—— Black Rocks	9	39	114	56
	—— Bank	10	18	115	7
	—— White Sand	10	48	115	13
	—— Low Black Island	11	1	115	17
	Friendship's Shoal	5	52	112	34
		6	00	112	49
	Hardwicke's Reef* (or Dolphin's)	9	54	112	17
	—— Breakers* (ditto)	10	2	112	12
	Royal Captain's Shoal	9	4	116	40
	Bombay's Shoal	9	27	116	57
	Dolphin's Reef* (or Hardwicke's)	9	59	112	17
	—— Breakers*	9	45	112	30
	—— Breakers* (ditto)	10	8	112	15
	—— Great Reef, N. p.*	10	7	112	9
	—— Long Island*	10	17	112	35
	—— Breakers*	10	22	112	31
	—— First Island*	10	35	112	38
	—— Ledge*	10	40	112	47
S. E. Part China Sea.	—— Breakers*	10	46	112	47
S. E. Part China Sea.	Breakers*	11	10	112	54
S. E. Part China Sea.	Falmouth's (or Essex) low Island*	10	58	112	40
S. E. Part China Sea.	—— Bank, or Gossard's Bank,	11	25	114	13
S. E. Part China Sea.	Essex (or Falmouth) low Island*	11	2	112	40
S. E. Part China Sea.	Gossard's Reef (or Middleburgh R.)	8	58	111	5
S. E. Part China Sea.	Small Island	10	42	113	26
S. E. Part China Sea.	Cornwallis Breakers	10	00	114	22
		8	52	114	12
	Sabut Jung low Island	11	32	113	29
	———— Bank	11	34	113	51
	Gaspar Shoals	11	36	113	51
	South Sea Castle's Sandy Islands and dangers, limits (by Lieut. Ross)	11	29	114	20
		11	21	114	16
	Two Islands	11	27	114	22
	An Island (Investigator)	11	8	114	18
	An Island, ditto	10	44	114	26
	A Reef	10	15	113	40
	Discovery's Reef	10	00	113	50
		10	8		
	York Breakers, W.	9	55	117	55
	Pennsylvania Breakers	8	17	114	43
	....	8	50	115	17
	(Viper's)	8	58	115	21
	....	9	4	115	20
	....	10	00	115	12
	(Fanny)	9	48	114	40
	....	9	32	116	28
	....	9	49	116	47
	....	9	52	116	48
	....	10	25	116	37
	....	10	52	116	55

* The longitudes of these places ought probably to be increased.

Digitized by Google

TABLE LIV.

Latitudes and Longitudes

XLIV. *Islands and Shoals between Batavia and New Guinea, South of the Celebes.*

	Lat.		Long.	
	D.	M.	D.	M.
Java Sea.				
Carimon Java, W. ex.	5	50 S	110	3 E
Lubeck or Babian Island.	5	49	112	48
Arrogant's Shoal	5	12	113	00
Madura Island, N. W. p..	6	53	112	45
——— N. E. p..	6	53	113	58
Pondy Island	7	1	114	4
Great Solombo Island, (hill on S. E. p.)	5	33	114	24
Little Solombo Island	5	21	114	25
Arentes Island	5	10	114	32
Little Pulo Laut, (middle)	4	51	115	53
Four Brothers, sunken Islands	7	00	114	50
Urk Island	7	5	115	16
Paternosters.				
Kangelang or Cangayang Island, N. p.	6	50	115	17
—— S. p.	7	19	115	25
—— S. E. Island, or Hastings's Island	6	54	116	11
Kalkoon Islands, northern, about	6	10	115	46
Four small islands, middle	7	11	115	50
Great Paternoster Islands, W. p.	7	15	117	00
——— S. W. Island	7	32	117	16
——— S. Island	7	34	117	30
——— Two low Islands	7	36	117	55
——— E. p.	6	42	118	30
Postilion's Islands, N. W. p.	6	32	118	46
—— Eastern Island	6	45	119	15
—— S. post	6	58	118	56
Noesa Sera Islands	5	2	117	9
Noesa Comba, about	5	15	117	9
Sd. Bank off Noesa Comba	5	52	117	10
Caloeolrij or Rotterdam Island	5	12	117	38
Hen and Chickens, S. p..	5	28	117	54
Zalinaff, or Saflanaff, or Laer's Island	5	31	118	34
—— Coral Bank off ditto, S. p.	5	54		
—— ditto E. p.			118	26
—— ditto W. p.			117	58
—— Five Fathoms Bank	5	52	118	20
Tonyn Islands, S. W. Isl.	5	31	118	36
——— E. Island	5	33	118	50
Shoal	5	27	119	5
Tanakeka or Tunikik Isl.	5	34	119	24
Brill Shoal, N. p.	6	00	119	2
——— S. p.	6	5	119	0
Mansfield Shoal	5	45	120	17
Middle Island	5	40	120	28
Salayer Island, N. p.	5	47	120	28
Cambyna Island, S. p.	5	30		
—— Peak	5	21	121	57
South Island	5	45	122	28
Hegadis Island	6	13	122	40
Bouton Island, S. p.	5	42	122	44
—— Town	5	27	122	48
—— N E. point	4	23	123	4
—— Calansoese Harbor.	4	55	123	11
—— E. point.	5	15	123	15
Token Bessy's Islands, — Wangiwangi, N. W. Isl.	5	18 S	123	33 E
— Pinnunko, S. lim.	6	5	123	56
— Velthoens or Koko Island	5 6	58 10	124	43
St. Matthew's Islands, (middle)	5	18	124	16
Mamalakjee Island, (N. W. Tonin Island,)	6	41	120	14
Schiedam Islands, N. W.	7	1	120	28
——— S. E..	7	12	120	56
——— Shoal.	7	27	121	13
Kalatoa Island	7	12	121	43
Alfred's Shoal	7	9	121	39
Jagger's Reef, or Bangalore Shoal, about	7	40	121	13
——— another estimate.			121	46
Angelica's Shoal	7	55	121	25
——— another estimate	7	40	122	18
Rusa Raji or Lusardy Isl.	8	17	121	36
Rusa Linguette or Rosagalet Island	8	5	122	3
The Three Bastards	8	14	122	41
Straits East of Java.				
Bally Island, — Table Point, or S. p.	8	50	115	2
— Volcano	8	21	115	27
— N. E. p.	8	18	115	43
Bally Straits, S. entrance	8	50	114	40
A shoal near the anchorage at Balambuang, bears S. W. ½ W. from the flagstaff, distant ¾ mile from shore.				
Mynder's Rocks	7	41	114	22
Banditti Island, S. E pt.	8	51	115	29
Lombock Isl., S. p. about	8	50	116	00
—— Peak, near N. E. p..	8	26	116	26
—— N. E pt.	8	19	116	43
Lombock Island, —— Isles near N. W. p..	8	13	115	59
—— Ampannan River, entrance	8	33		
—— Loboagee or Bally Town	8	42	116	33
Selonda Island	8	8	117	44
Pulo Majo or Mayo, N. p.	8	7	117	37
Flat Island	8	7	117	28
Sandbuy's Four Shoals, limits	7 7	42 56	117 118	13 3
Sumbava Island, S. W. p.	9	2	116	42
—— Timor Yung Island, (off N. W. p)	8	21	116	57
—— Sumbava Bay	8	27	117	24
—— Tumbora Mountain.	8	15	117	55
—— Biema Bay, rugged point	8	11	118	41
—— ditto, rocky point	8	8	118	36
—— Sapy Bay, anchorage	8	30	119	3
—— S. E. Point	8	42	119	14
Goonong Apee Isl. Peak.	8	11	119	5
Comodo Island	8	22	119	37
Flores or Mangerye Island, S. W. p. about	8	48	119	54
— S. p. about	9	00	121	30
— Lobetobie Volcano	8	35	122	48
— N. p. Flores Head, or Iron Cape	8	1	122	50

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat.	Long.
		D. M.	D. M.
	Straits of Flores, S. ent. Id.	8 38 S	122 58 E
	Sandal Wood Isl., N. p.	9 15	
	—— Bluff or W. p.	9 42	119 00
	—— S. extremity	10 22	120 35
	—— E. end	10 00	120 51
	—— Padewawy or Baring's Bay	9 40	120 18
	Savu Island, W. pt.	10 32	121 35
	New Island, S. pt.	10 49	121 10
	——		
	Pulo Comba or Cambay	7 49	123 38
	Lomblen Island Peak (on N. W. p.)	8 12	123 47
	—— E. p.	8 14	123 35
	Pantar Island, N. E. p.	8 10	124 20
	East Island, Strait of Aloo	8 20	124 00
	Middle Island, ditto	8 23	123 55
	Ombay or Mallao Island, N. W. p.	8 9	124 27
	—— E. p.	8 15	125 15
	Rotto or Rotte Isl., S.W. p.	11 2	122 55
	— Booca Bay, on S. side.	10 53	123 5
Timor Island.	Timor Island, S. W. p.	10 23	123 30
	— Copang, Fort Concordia	10 9	123 35
	— Peak	9 41	124 11
	— N. W. point	9 24	123 55
	— Tulycaon Bay	9 12	124 23
	— Batto-gady	8 57	124 50
	— point nearest Ombay	8 39	125 13
	— Dilly, or Diely	8 33	125 34
	— E. end	8 21	127 13
	Pulo Batto	9 14	123 52
	Pulo Cambing or Passage Island, S. p.	8 18	125 29
	———— N. p.	8 11	125 43
	Wetter Island, E. p.	7 46	126 54
	—— Pulo Baby, near S. W. p.	8 05	
	Goonong apy or Burning Island	6 35	126 40
	Dog Island	7 41	125 56
	Kisser Island	8 6	127 7
	Pulo Jackee, or Noosa Nessing	8 21	127 13
	Lettee Island, W. p.	8 14	127 40
	Roma Island	7 42	127 26
	Lucapin-hay or Lucepera Island	5 40	127 21
	Turtle Islands, eastern	5 25	127 38
	Cerowa Island, about	6 10	129 53
	Babber Island, about	7 25	130 40
	Timor Laut, S. & W. end	8 27	131 7
	Arroe Island, S. extr.	9 00	135 00

XLV. *Borneo, Celebes, Luconia, with the adjacent Islands and Shoals, as far East as New Guinea.*

		Lat.	Long.
		D. M.	D M
Borneo.	Tanjong Sambar, S. W. p.	2 53 S	109 58 E
	Succadana	1 16	110 0
	Tanjong Factie	1 16	109 35
	Pontiana or Lewa R., ent.	0 2 N	109 10
	Point Mampava	0 17	109 00
	Slackoo Road	1 4	
	River Sambas, entrance	1 13	108 58

		Lat.	Long.
		D. M.	D. M.
Borneo.	Tanjong Apee	1 58 N	109 19 E
	Tanjong Datoo	3 00	110 36
	BORNEO Road	5 00	115 00
	Pulo Teega	5 45	115 35
	Abai Harbor	6 21	116 20
	Keeney Balloo Mountain	6 8	116 36
	Tanjong Sampanmangio, N. p.	7 1	116 46
	Point Unasang	5 17	119 2
	Point Kanneeoongan	1 3	118 50
	River Passier, entrance	1 44 S	116 26
	Ragged Point	2 10	116 33
	Shoal Point	2 33	116 25
	Point Salatan, S. p.	4 10	114 42
	——		
Celebes.	Point Layk, S. W. p.	5 37	119 25
	MACASSAR Town, fort	5 9	119 23
	Cape Mandhar	3 35	119 2
	Cape William	2 37	118 50
	Cape Temoel or Samsa, S. p.	0 8	
	———— N. W. p.	0 1 N	119 37
	Cape Donda	0 48	119 57
	Cape Rivers	1 20	120 45
	Manado, fort	1 29	124 50
	Cape Coffin	1 42	125 11
	Isle Banca, E. pt.	1 43	125 12
	Kema Village	1 19	125 4
	Castican Bay	0 48	125 00
	Goonong Tella River	0 28	123 0
	Cape Talabo, E. pt.	0 55 S	123 30
	Weywongy Island, about	4 3	
	Waxway Island, middle	3 34	123 14
	Cambyna Island Peak	5 21	121 57
	Middle Island	5 40	120 28
	Boele-comba Hill	5 33	120 9
	——		
Straits of Macassar.	Waller's Shoals and Laurel Rocks, limits	4 30 4 37	117 7 117 15
	Noesa Sera Islands	5 2	117 9
	Noesa Comba	5 15	117 9
	Shoal off Noesa Comba	5 26	117 0
	Little Pulo Laut Isl., mid.	4 51	115 53
	Moresses or Manevessa Island	4 25	115 50
	Dwaalder Island	4 12	116 5
	Royal George Shoal	4 17	116 14
	Two Brothers	4 26	116 11
	Great Pulo Laut, N. E. p.	3 23	116 20
	— N. p.	3 13	
	— S. Isl. off the S. E. p.	4 5	116 11
	The Three Alike Islands	3 39	116 37
	Dry Sand Bank	3 37	117 48
	Triangle Islands, middle	3 3	117 53
	Little Paternosters, S. p.	2 50	
	———— N. E. p.	2 10	117 44
	———— N. W. p.	2 8	117 28
	Pamaroong or Dondrekin Island, S. p.	0 51	117 33
	Seven Islands	0 32	119 40
	——		
	Banguey Peak	7 19 N	117 6
	Balambang Isl., N. Harb	7 16	116 58
	Balabac Island, (hill,)	7 59	116 56
	Mangsee Islands*	7 32	117 19
	St. Michael's Islands, (Bangcawang,)	7 48	118 46
	Toob-Bataha Shoal, S. extr.	8 00	119 50

* See Table on page 451

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat.		Long.	
		D.	M.	D.	M.
Soolo Sea.	Palawan, W. end	8	24 N	117	14 E
	——— N. p.	11	30	119	37
	Ragged Island	11	15	119	21
	Cagayan Soolo	7	00	118	28
	Soolo Island, town*	6	3	121	1
	Takoot Paboonoowan Shoal	6	15	121	32
	Pangootaran Island	6	15	120	40
	Belawn Island, E. p.	6	00	122	8
	Tapeantana Island, E. p.	6	14	122	8
	Tamook Island	6	28	121	56
	Mataha Island, S. p.	6	32	121	50
	Peelas Island, N. p.	6	41	121	45
	Ballook Ballook	6	47	121	50
	Basilan Island, E. p.	6	41	122	17
	Santa Cruz Island	6	50	122	12
	Sangboys or Hare s Lips.	6	46	121	30
	Teynga Island, N. ex.	6	52	121	27
	——				
	Catanduanes Island, S. p.	13	38	124	2
	Cape del Espiritu Santo, N. E. p. Samur Island.	12	34	125	15
	St. Bernardino Island	12	46	124	14
	Ticao Island, Port St. Jacinto	12	34	123	46
	——				
Luconia.	Manilla	14	36	121	2
	Cavite	14	29	120	55
	Entrance Manilla Bay	14	28		
	Point Capones	14	52	120	3
	Two Sisters Islands	15	50	119	49
	Point Boliano	16	27	119	51
	Cape Bajador	18	42	121	00
	Point Cavnaion	18	48	121	14
	Cape Enganno	18	39	122	16
	Mauban	14	8	121	44
	Cape St. Ildefonso	15	27	121	46
Mindanao.	Samboongan	6	55	122	8
	Point Balagonan	7	51	122	6
	Suriago Village, near N. point	9	47	125	25
	Cape St. Augustine, S. E. p.	6	4	126	13
	South Point	5	39	125	18
	Mindanao	7	10	124	35
	——				
Panay.	Negros, S. point	9	6	122	56
	——— Point Sojoton	9	50	122	24
	Cagayancs Islands, middle	9	34	121	23
	Panay Island, Point Nasog, S. p.	10	25	122	6
	— Asloman village	10	32	122	6
	— Point Potob or N. p.	11	46	121	56
	Dry Sand Bank	11	24	121	34
	Sombrero Rock	10	45	121	15
	White Rock	10	28	121	5
	Cuyos Islands,				
	— Quiniluban (Northern Island) W. ex.	11	30	120	47
	— Grand Cuyo	10	52	121	15
	— Southern Island	10	40	121	13
	Caravos or Buffalos	11	53	121	48
	Betsey's Bank, 5 fathoms	11	42	120	57
	Ylin Islands, S. p., off S. p. Mindoro	12	9	121	15
	Coral Shoal, W. of ditto, about	12	11	120	57

		Lat.		Long.	
		D.	M.	D.	M.
Apo Bank.	Apo Bank, S. p.	12	36 N	120	33 E
	— E. p.	12	40	120	36
	— N. p.	12	45	120	31
	— S. W. p. Islet	12	40	120	29
	— West or Great Islet	12	39	120	28
	— Discovery Bank	12	40	120	43
	Coron Island, Is. off N.E.p.	11	59	120	36
	Green Island	12	3	119	49
	Hayock	12	9	119	51
	Pinnacle Rock	12	18	119	54
	N. W. Rock	12	23	119	55
	Sail Rock	12	22	119	56
	Busvagnon Island, N. p.	12	19	119	56
	Calavite or High Island	12	21	119	56
	Group of Islands, S. p.	12	8	120	23
	——— N. p.	12	17		
Mindoro.	Turret Island	12	22	120	10
	North Rock	12	27	120	4
	Mindoro Island, S. p	12	11	121	22
	—— Point Dongan or Pandan	12	46	120	47
	—— Point Calavite	13	28	120	26
	Luban, N. pt.	13	52	120	8
	Goat Island	13	55	120	3
	Babuyan Islands,				
	—— Lapurip or Daluperi Island	19	15	121	10
	—— Fuga or New Babuyan Island	19	1	121	20
	—— Camiguin Island	19	0	121	53
	—— Guinapac Rocks	19	5	122	5
	—— Didicas Rocks	19	12	122	12
	—— Claro (or Old) Babuyan	19	37	122	12
	—— Calayan Island	19	28	121	46
Bashee Islands.	Bashee Islands,				
	—— Balintang or Richmond Isles, N. one	19	58	122	12
	—— Sabtang Island, S. pt	20	17	121	53
	—— Bashee Island	20	14	122	9
	—— Goat Island	20	21	121	48
	—— Batan or Monmouth Island, S. p.	20	17	122	15
	—— ditto Mount, N. p.	20	28	122	1
	—— Grafton or High Round Island	20	41	121	57
	—— Bayat or Orange Isl.	20	47	121	53
	North Bashee, High Isl.	21	3	121	57
	——— northernmost Isl.	21	9	121	59
	Gadd's Reef	21	43	121	41
	Cumbrian's Reef, doubtful; probably the same as Gadd's Reef	21	35	121	43
	Little Botel Tobago Xima	21	56	121	41
	Botel Tobago Xima	22	5	121	38
	Vele-rete Rocks	21	42	120	49
	Formosa Island, South Cape	21	56	120	56
	——				
Xulla Besseys.	Gomano Island	1	46 S	127	27
	Lissamatula Isl., S. E. p.	1	46	126	27
	Xulla Bessey, S. & E. p.	2	28	126	7
	——— N. E. p.	1	58		
	——— N. W. p.	1	58	125	48
	Xulla Mangola, W. end	1	43	125	21
	Greyhound Straits {	1 1	40 56	124	30

* See Table on page 451

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

Region	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
	Haycock Island, off S. W. p. Xulla Talaybo	1	47 S	124	24 E
	Skelton's Island, on N.W. p. ditto	1	45	124	36
	Middle Island	1	45	124	28
	Albion's Island.........	1	53	124	19
	Bouro Island, N. W. p...	3	4	125	57
	—— N. extr...........	3	2		
	—— N. E. p...........	3	49	127	10
	—— Cajeli or Bouro Bay.	3	22	127	6
	—— S. point...........	3	54	126	37
	Amblaw Island.........	3	49	127	10
	Manipa Island, E. pt.....	3	24	127	40
	Bonoa Island, about.....	3	00	127	56
Ceram.	Ceram Island, Seeal, or S. W. p..............	3	33	127	51
Ceram.	—— Kessing, or E. p.....	3	55	131	10
Ceram.	—— Waroo Bay.........	3	25	130	45
Ceram.	—— Old Lamata or Flat P.	2	53	129	42
Ceram.	—— Sawa Bay..........	2	51	129	6
	Leeuwarden Island, S. pt.	3	20	130	48
	———— Shoal.......	2	56	130	43
	Goram Island..........	4	00	131	44
	Matlabella Islands	4	30	131	47
Banda Sea.	AMBOYNA Island, Fort Victoria	3	41	128	10
Banda Sea.	Noesa Laut Island, E. pt.	3	42	128	49
Banda Sea.	Banda Island, anchorage.	4	31	130	00
Banda Sea.	Lookisong or Landscape Island, S. p...........	1	39	128	4
Banda Sea.	Pulo Gasses, S. p.	1	41	128	15
	Kekik	1	33	128	35
	Pulo Pisang............	1	23	128	53
	Horsburg's Rocks	1	8	128	20
	Boo Islands	1	12	129	20
	Weeda Islands..........	0	32	128	35
	Kanary Islands, Grand K.	1	44	129	42
	—— Efbe Harbor	2	12		
	Pulo Popo, S. E. p.......	1	12	129	52
	Battanta Island, Cape Cambo, W. p	0	56	130	25
	Fisher's Island..........	0	56	130	23
	Waygecooe Island, S. E. p., or Point Pigot	0	21	131	18
	—— Offak Harbor	0	01	130	43
	—— Boni Road	0	01	131	5
	Amsterdam Island	0	19	132	9
	Fow or Faux Island.....	0	6	129	28
	Gagy Island, N. pt.	0	24	129	53
	Geby Island, N. W. end.	0	2 N	129	19
	Syang Island	0	22	129	55
	Eye Island	0	23	129	51
	Islet E. of Pulo Moar....	0	9	128	58
	Catharine's Islands	0	39	129	11
	Canton Packet Shoal....	0	35	128	55
	Ormsbee's Shoal, N. pt. .	0	46	130	4
	Ditto soundings, 15 fath..	0	42	130	3
	Yowl or Aiou Islands,				
	— Aiou, the largest Isle .	0	21	131	0
	— N. W. Island........	0	38	131	8
	— N. E. Island........	0	36	131	15
	— Reef N. part........	0	41		
	Asia's Islands, S. W. Isle	1	04	131	21
	———— N. E. Island...	1	4	131	23
	Gillolo Island, N. end ...	2	23		
	— Ossa village	0	45	128	22
	— Maba village	0	53		
	— Islet near Pulo Moar..	0	9	128	58

Region	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
	Gillolo Island, point entrance Straits Patientia	0	13 S	127	45 E
Moluccas.	— Cocoa-nut Point, or S.p.	0	51	128	22
Moluccas.	Batchian Island, S. E. p..	0	48	128	3
Moluccas.	Amsterdam Island	0	20	127	53
Moluccas.	Kayo or Cayo Island, S. p.	0	1	127	23
Moluccas.	———— N.p.	0	7 N		
	Negory Kalam, N. p.....	0	28	127	37
	Wolf Rock.............	0	20	127	9
	Tidore Island, S. extr...	0	34	127	24
	———— Mountain	0	40	127	25
	———— N. E. end	0	46	127	34
	Ternate Island	0	49	127	19
	Tyfore Island	1	8	126	12
	Meyo Island............	1	22	126	25
	Morty or Mortay Island, (N. cape,)............	2	44	128	25
	Bangay Island, peak.....	1	52	125	24
	Tagalondo	2	23	125	36
	Bejaren Island. peak....	2	6	125	25
	Siao Island, S. point	2	40	125	35
	———— peak	2	43	125	35
	Sangir Island, S. end....	3	21	125	46
	— Watering place on the W. side	3	28	125	44
	— N. end.............	3	46	125	44
	Glatton's Rock.........	3	50	126	4
	Sallibobo or Toulor Isls.				
	—— Kabruang, S. p....	3	47	127	0
	—— Tulour or Karkalang, N. p.	4	28	126	55
	Meangis or Menangus Isl.	5	00	127	17
	Serangi Islands, S. p.....	5	20	125	35
	—— peak on W. Island .			125	32
	—— N. p..............	5	31	125	43

XLVI. *The Coast from CANTON to KAMTSKATKA, with the adjacent Islands and Shoals.*

Region	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
	CANTON	23	7 N	113	14 E
	Mir's Bay Paint........	22	27	114	30
	Single Island, or Chueng Chow	22	24	114	40
	Mendoza's Island	22	31	114	50
	Fokoi Point	22	33	114	54
	Pedro Branco	22	18.5	115	07.8
	Point Chelang	22	39	115	35
	Point Tongmi	22	44	115	49
	Point Cup-chi	22	49	116	4
	A black conical Mount..	22	52	116	8
China.	Breaker Point..........	22	56	116	28
China.	Cape of Good Hope.....	23	14	116	47
China.	Fort Island	23	25	116	51
China.	Lamo or Namo Isl., W. p.	23	26	116	55
	———— N. pt...	23	29	117	8
	Lamock Island, S. W. Rk.	23	11	117	14
	The Brothers, southern..	23	32	117	42
	Chapel Island	24	10	118	14
	Amoy	24	28	118	4
	Chin Chew Bay, mid....	24	48	118	47
	* Lamyet Islands, E. Peak.	25	12	119	35
	Ting-hae harbor........	26	18	119	50
	Hiesham Group Saddle Id	28°	51	122°	14
	Quesan Isl's Patahecock..	29	22	122	14

* White Dogs S. P. 25° 57 120° 01

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

		Lat. D.	Lat. M.	Long. D.	Long. M.
	Chusan Island, Tinghae..	30	1 N	122	6 E
	Saddle Group N; Is.......	30	50	122	41
	Chin-san Island............	30	25	122	21
	Amherst Rocks............	31	10	122	22
	Shang-Tung Prom. S. p.	37	00	122	41
	— N. p.................	37	25	122	45
	Cape Zeu-ou-Tau	37	36	121	28
	Ten-choo-Foo City......	37	48	120	40
	Tchoo-san Island.......	38	0	121	2
	Keusen Islands, northern	38	8	120	43
	Pekin River, anchorage at Peiho Entrance.....	38	58	117	48
	Alceste Island, S. W. extr. Corea...........	34	7	125	21
	Cape Clouard	36	3	129	45
	Sanpon..................	37	44	128	55
	Ternai Bay	45	15	136	30
	Suffren Bay..............	47	51	138	44
	Cape Lesseps	49	30	141	30
Tartary.	Castries' Bay............	51	29	141	0
	Vanjuas Point............	52	7	142	42
	Bay de Langle...........	47	44	141	57
	Bay d'Estaing...........	48	59	141	27
	Monneron Island........	46	8	141	11
	La Dangereuse Rock....	45	47	142	9
	Cape Crillon, (entrance Perouse's Straits,)....	45	54	141	58
	Cape Aniwa	46	2	143	30
	Cape Lowenorn	46	23	143	40
	Bay Mordwinoff........	46	48	143	14
	Cape Tonyn	46	50	143	33
	Point Siniavin..........	47	16	143	00
	Mount Spenberg or Bernizet	47	33	142	20
	Point Muloffsky.........	47	58	142	44
	Cape Alexander Dalrymple...................	48	21	142	50
	Cape Soinsonoff.........	48	52	143	2
	River Neva, entrance....	49	15	143	2
	Gulf Patience, N. p.	49	19		
	Robber Island Reef, N. E. p.	48	36	144	33
	— S. W. p..............	48	28	144	10
	Cape Patience...........	48	52	144	46
Sachalin.	Cape Billinghausen.....	49	35	144	26
	Mount Tiara	50	3	143	37
	Cape Ratmanoff.........	50	48	143	53
	Cape Croyere	51	00	143	43
	Downs Point............	51	53	143	13
	Shoal	52	30	143	29
	Wurst Point............	52	57	143	18
	Cape Klokatschef.......	53	40	143	7
	Cape Lowenstern.......	54	3	143	13
	Cape Elizabeth.........	54	24	142	47
	North Bay.............	54	16	142	37
	Cape Maria	54	17	142	18
	Espenberg Peak........	54	4	142	50
	Cape Golowgtscheff.....	53	32	141	55
	Cape Romberg	53	26	141	45
	Cape Chavaroff..........	53	38	141	26
	Jonas Island............	56	25	143	16
Russia.	Ochotsk	59	20	143	12
	Yamsk	60	46	154	30
	Bolcheretsk............	52	54	156	50
	C. Lopatka, Kamtskatka	51	2	156	46
	St. Peter and St. Paul...	53	0	158	44

		Lat. D.	Lat. M.	Long. D.	Long. M.
	Shipunskey-noss, Cape ..	53	6 N	160	4 E
	Nisjui Kamtskatka......	56	16	162	00
Russia.	Cape Tschulkolskoi.....	64	13	171	24 W
	East Cape	66	6	169	40
	Cape Serdze Kamen....	67	12	171	49
	North Cape	68	56	179	57
	Formosa Island, S. cape	21	56	120	56 E
	——— N. W. point.	25	11	121	6
	——— N. point.....	25	18	121	34
	——— N. E. point..	25	11	121	56
	Lamay Island	22	19	120	27
	Pehoe or Pescadore Isles,				
	—— Southern limit.....	23	11	119	23
	—— High Isl., S.W. limit	23	19	119	16
	—— Pachan Island.....	23	32	119	26
	—— Northern limit.....	23	47	119	32
	—— Treble I. S. E. p....	23	31	119	39
	—— ditto, nine feet reef .	23	28	119	41
	Pat-chow or Madjicosemah Islands,				
	—— Southernmost Island	24	6	123	52
	—— Bluff Point, W. ext. Great Island	24	17	123	45
	—— Kumi Island.......	24	25	123	00
	—— Eastern Island, Ty-pin-san..............	24	42	125	29
	—— Providence Reef...	25	6	125	6
	Lew Chew Islands,				
	—— Great Lew Chew, } From	26	03	127	34
	} To	26	53	128	25
	—— ditto, adjacent Island, N. p.	27	34		
	—— Western Island....	26	20	127	17
	Hoapinsu Island.........	25	47	123	29
	Ty-ao-yu-su Island......	25	57	123	40
	Sulphur Islet............	27	51	128	14
	————Island...........	24	48	141	20
	————Ousima.........	28	16	120	21
	Group of seven Islands, limits {	29	25	129	38
	{	30	06	130	04
	Pinnacle Islands.........	29	52	129	52
	Ormsbee's Peak	29	40	140	20
	A Rock..................	30	45	123	46
	South Island............	31	30	140	00
	Gotto Island, S. end	32	35	128	44
	Asses' Ears..............	32	3	128	37
	Quelpaert Island, S. p...	33	8	126	19
	Kiusiu Island,				
	—— Cape Tschirikoff...	32	14	131	41
	—— Cape Danville.....	31	27	131	27
	—— Cape Nagaeff......	31	15	131	11
	—— Mount Schubert ...	31	41	131	12
	—— Mount Horner, peak	31	9	130	28
	—— Cape Tschitschagoff, S. p.	30	57	130	36
	—— CapeTschesma, W.p.	31	24	130	2
	—— Cape Kagul, N. p. .	31	42	130	7
Japan Islands.	—— MountUnga, volcano	31	43	130	14
	—— Nangasaky harbor, entrance............	32	44	129	46
	—— Cape Nomo, S. p. of Bay Nan	32	35	129	42
	—— Cape Seurote......	32	58	129	35
	Sanao-sima Island, N. p..	30	42	131	00
	——————— S. p..	30	24		
	Tenegasima Isl., (middle)	30	23	130	36

TABLE LIV.

Latitudes and Longitudes.

		Lat. D.	Lat. M.	Long. D.	Long. M.
Japan Islands.	Volcano Island	30	43 N	130	17 E
	Seriphos Island	30	43	130	44
	Apollo Island	30	44	130	24
	Julie Island	30	27	130	13
	St. Claire Island	30	45	129	54
	Symplegados Islands, N. E. p.	31	30	129	42
	— S. W. p.	31	26	129	37
	Meac-Sima Isl., S. W. p.	31	35	129	40
	——— N. E. p.	31	49	129	51
	Nadeshda Rocks	31	42	129	33
	Tsus Island, S. end	34	6	129	17
	—— Cape Fida-Buengono	34	19	129	30
	—— N. p.	34	40	129	29
	Colnett's Island	34	16	129	56
	Dagelet Island, N. E. p.	37	25	130	56
	Niphon Island,				
	— S. p.	33	25	135	47
	— Cape Noto	37	36	137	20
	— A Rock	37	36	136	50
	— Jootsi-Sima	37	51	136	56
	— Jedo	35	40	140	00
	— Cape Kennis	37	10	141	30
	— Zach's Mountain	35	25	132	20
	— Russian's Promontory, S. p.	39	46	139	44
	— N. E. p.	40	00		
	— Town	40	50	140	6
	— Cape Gamally	40	38	139	48
	— Peak Tilesius	40	40	140	11
	— Cape Greig	41	9	140	8
	— Cape Sangar, (ent. Straits of Sangar,)	41	16	140	14
	Osima Island	41	31	139	19
	Kosima Island	41	21	139	46
	Okosir Island, (middle,)	42	9	139	30
	Jesso Island,				
	— Cape Nadeshda, (ent. of Straits of Sangar,)	41	25	140	9
	— Cape Sineko	41	38	133	53
	— Matzumay Town	41	32	140	4
	— Cape Oota-Nizawu	42	18	139	46
	— Cape Kutusoff	42	38	140	1
	— Cape Rayten	42	57	140	16
	— Cape Okamay, S. p.	43	11	140	13
	— Cape Taka-sima	43	21	140	31
	— Mount Rumoffsky	42	50	141	11
	— Cape Malespina	43	42	141	18
	— Cape Schischkoff	44	20	141	37
	— Pallas Mountain	44	00	141	54
	— Cape Romanzoff, N. p.	45	26	141	34
	— Cape Soya	45	31	141	51
	— Cape Shaep	45	21	142	12
	Peak de Langle, Rioschery Island	45	11	141	12
	Cape Guibert, Reifunschery, N. E. p.	45	28	141	4
	Jeurire Island	44	28	141	17
	Janikesseri Island	44	29	141	22
	Staten Island, S. W. end	44	26	147	28
	— Cape Vries, (Vries Straits,)	45	26	149	43
	Company's Island,				
	— Cape Shouten	46	18	150	58
	— N. end	46	28	151	20
	Marikan Island, N. end	47	10 N	153	6 E
	—— S. end, (Bousole Sts.)	46	46	152	32
	Sarytscheff Island Peak	48	6	153	12
	Raakok Island	48	8	153	15
	Mussir Island	48	16	153	15
	Trap Rocks	48	36	153	44
	Charamukatan Isl. Peak	49	8	154	39
	Poromuschir Island, S. p.	50	0	155	24
	—— Peak Fuss, (S.W.p.)	50	15	155	10
	—— E. p.	50	28	156	9

XLVII. *NEW HOLLAND and the adjacent Islands and Shoals.*

		Lat. D.	Lat. M.	Long. D.	Long. M.
Van Dieman's Land.	Pedro Branco, (Rubrick,)	43	59 S	147	43 E
	South-west Cape	43	37	146	0
	Mew Stone	43	46	146	31
	South Cape	43	40	146	59
	Eddystone	43	51	147	4
	Sidmouth's Rock	43	46	147	11
	Tasman's Head	43	30	147	10
	D'Entrecasteaux's Chann.	43	32	147	12
	Adventure Bay	43	17	147	32
	Frederick Henry Bay	42	58	147	42
	Cape Pillar	43	12	148	6
	Oyster Bay	42	40	148	2
	St. Patrick's Head	41	42	148	17
	Cape Portland	40	44	147	57
	Port Dalrymple	41	3	146	48
	Circular Head	40	46	145	17
	Cape Grim, N. W. prom.	40	41	144	42
	West Cape, or Sandy Pt.	41	1	144	35
	Macquarie's Harbor	42	12	145	18
	Rocky Point	43	0	145	31
	Port Davey	43	22	145	59
	Ent. to Banks's Straits	40	40	148	20
	Furneaux Islands,				
	— Barren Isl., S.E. ext.	40	26	148	31
	— Clarke's Isl., S. ext.	40	36	148	12
	— N. Sister, near N. p. of Great Island	39	38	148	01
	Endeavor Rock	39	37	147	6
	Kent's Group Light	39	30	147	21
	The Pyramid	39	49	147	16
	Waterhouse Island	40	48	147	37
	Hunter's Islands,				
	— Black Pyramid, W.	40	28	144	22
	— Albatross Isl., N. W.	40	22	144	39
	King's Island, C. Wickam	39	35	143	58
	W. ent. Bass's Straits	39	23	143	40
New South Wales.	Cape Albany Otway	38	52	143	34
	Port Philip, Pt. Nepean	38	18	144	40
	Western Port, Phillip I.	38	27	145	18
	Wilson's Promontory, S. ext.	39	8	146	24
	Ram Head	37	39	149	45
	Cape Howe	37	30	150	0
	Cape Dromedary, Mt.	36	16	150	9
	Jervis Bay, N. pt.	35	7	150	58
	Red Point	34	29	151	00
	Botany Bay, entrance, (Cape Banks,)	34	02	151	13
	Port Jackson, entrance	33	50	151	18

TABLE LIV.

Latitudes and Longitudes.

New South Wales.

	Lat. D.	Lat. M.	Long. D.	Long. M.
Broken Bay	33	34 S	151	20 E
Port Stephens, pt.	32	41	152	14
Cape Hawke	32	15	152	31
Smoky Cape	30	56	153	5
Solitary Islands	30 29	13 56	153	18
Cape Byron	28	38	153	38
Point Danger	28	7	153	31
Shoals off ditto	28	7	153	39
Cape Morton	27	3	153	27
Shoal, Dry Rocks	26	56	153	31
Sandy Cape Sh'l, 9 ft. rock	24	36	153	22
Group Capricorn, N. W. Is.	23	18	151	43
Keppel I.	23	11	151	08
Barrier Reef, S. extreme	22	23	152	37
Cape Townsend	22	14	150	29
Cape Palmerston	21	30	149	28
Cape Hillsborough	20	54	149	06
Cape Conway	20	32	149	0
Cape Gloucester	20	2	148	26
Cape Cleveland	19	6	146	59
Cape Sandwich	18	10	146	19
Cape Grafton	16	48	145	57
Cape Flattery	14	55	145	16
Cape York	10	44	142	33
New Year's Island	10	55	133	03
Van Dieman's Cape	11	8	130	18
Red Island, off P. Vulcan	15	13	124	18
Minstrel's Shoal, N.W. pt.	17	14	119	10
Greyhound Shoal	19	58	114	40
Clarke's Reef, north of Rosemary Island	20	17		
Eastern Rosemary Island, N. E. p.	20	26		
Western ditto, N. p.	20	35	115	40
Doubtful Shoal	21	37	112	25
Piddington's Islands	21	36	114	56
Shoal (land of N. Holland in sight from the mast-head)	20	15		
North-west Cape	21	50	114	04
Dirk Hartog's Road, ent. to Sharks' Bay	25	22	112	57
Houtman's or Abrolhos Shoals, N. I.	28	18	113	35
Rottenest Island	32	3	115	31
Cape Leuwen or S. W. Cape, S. pt.	34	18	115	6
Cape Chatham	35	0	116	25
Cape Howe	35	9	117	38
King George III. Harbor	35	5	118	2
Point Hood, Rocks off	34	23	119	33
Termination Island	34	30	121	58
Endeavor, small island	36	27	127	2
Port Lincoln	34	43	135	55
Nepean Bay	35	44	137	55
Cape Jaffa	36	58	139	40
C. Northumberland. Rocks off	38	07	140	41

XLVIII. *Islands, Rocks, and Shoals, in the NORTH PACIFIC OCEAN.*

	Lat. D.	Lat. M.	Long. D.	Long. M.
Aleoutskia Islands,				
—— westernmost, W.p.	52	52 N	173	24 E
—— Ounalashka	53	54	166	32 W
Bank (64 fathoms)	33	22 N	178	30 E
Rica de Plata or Crespo	32	44	170	8
Reef	32	00	147	00
Island	31	30	140	00
Weeks's Reef, 36' N. E. and S. W.	31	15	153	9
Island	31	00	147	6
Ganges Island	30	45	154	25
Bank of Soundings	30	50	177	30
Island	30	00	137	00
Island	30	00	139	00
Island	30	00	141	30
Island	30	00	143	00
Island	30	00	144	24
Roca de Oro	29	54	157	3
Island, Rica de Oro	29	25	165	55
Island	29	33	137	00
Island	29	30	143	00
Island	29	35	174	43
Calunas Island	28	55	158	00
ditto (another account)	28	53	162	00
Island	28	30	176	50
Patrocinio Island	28	10	175	48
Disappointment Island	27	14	140	57
St. Juan	27	30	142	48
Bassiosos Island	25	58	173	31
Island	26	6	154	36
Reef	26	3	160	00
Copper Island	20	03	131	48
Tree Island	26	00	145	44
Lasker's Island	26	03	173	42
Island	25	53	131	17
Island	25	42	131	13
Reef	25	30	152	50
Bishop's Rock	25	22	132	00
North Island	25	14	141	14
Island	25	12	131	36
Grampus Island	25	10	146	40
Sulphur Island	24	48	141	20
Kendrick's Rock	24	35	134	00
Marcus Island	24	18	153	42
Weeks's Island	24	00	154	00
Dexter's Island	23	24	162	58
Island	23	3	162	57
Reef	22	6	142	28
Jardines	21	40	151	35
Parel or Peru Island	21	10	141	40
Abregoes Shoal	21	1	136	43
Reef	20	42	153	00
Douglas Reef	20	32	136	6
Lamira Island	20	20	164	15
Island	20	30	152	50
Bishop's Rock	20	16	136	53
Weeks's or Wilson's Isl.	19	11	166	55
Reef	19	28	166	29
Halcyon Island	19	6	163	33
Folger's Island	18	22	155	15
Reef	17	9	156	13
Tarquin Island	17	00	160	00
Reef	17	36	169	30
Island	16	00	171	42
Guy Rock	20	30	145	30
Urracas, about	20	10	145	25
Assumption Island	19	41	145	27
Almagan Island	18	5	145	54
Bird Island	16	1	146	13
Tinian	15	00	145	37

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

	Lat. D.	Lat. M.	Long. D.	Long. M.
Guam, Umatac Bay	13	17 N	144	40 E
Radack Islands.				
Radack chain of islands, viz. :—				
Aour, circular group of 32 islands, extending 13 miles N. W. and S. E., anchorage	8	19	171	12
Kaven group, 33 miles N. W. and S. E.				
— Araksheef Island, (largest island,)	8	54	170	49
— Southern Island	8	[illegible]	171	11
Chatham, circular group of islands, N. W. and S. E. 24 miles, Eregup	9	6	170	4
Chatham Is. circular group of 65 islands, E. and W. 30 miles, and 10 miles wide, enclosing a sea 12 miles wide and 27 miles long.				
—Otdia Island, eastern, (anchorage,)	9	28	170	16
Legiep or Hayden group	9	51	169	13
Ailou group, 15 miles long, 5 miles wide,				
— Krusenstern Capenius Island, (northern,)	10	27	170	00
Isle Du Nouvel An	10	8	170	55
Kutosoff or Udirick group, separated by a channel from a southern group called Souvoroff or Tagay, extending N. and S. 25 miles,				
— Channel	11	11	169	50
Group south of Kutosoff,				
—— Mille	6	16		
—— Medjuro	7	15		
—— Arno	7	25		
Bigar, north of Kutosoff.	11	48	170	07
Pescadores Isls,* eastern.	11	23	167	37
—— western.	11	8	167	22
Ralick Islands.				
Ralick chain of islands extend nearly N. and S. about one degree west of the Radack chain, viz. :—				
Ebon group	5	50	167	15
— Noamureck Island	5	30		
Kuli group	6	40		
Helut group	7	30		
Odia group	8	15		
Namou group	9	00		
—— Litel Island	8	55		
—— Tebot Island	8	30		
Quadelon group	9	20		
Oudia-Milai group	10	45		
Radogala group	11	00		
Bigini (northern)	11	20	167	15
Johannes	6	55	132	30
Lion's Island	5	16	132	13
St. Andrew's Island	5	20	132	16
Pulo Anna	4	38	132	3

	Lat. D.	Lat. M.	Long. D.	Long. M.
Pulo Mariere	4	19 N	132	28 E
Lord North's Island	3	3	131	4
Ganges Shoal, S. W. p.	2	52	131	7
—— N. E. p.	3	6	131	23
Helen's Shoal	3	0	131	55
Freewill or St. David's Islands, limits	0	49	134	17
	1	2	134	30
New Philippine or Caroline Islands.				
Pelew Islands,				
— Baubelthouap, E. p.	7	41	134	58
— Northernmost, Kyangle	8	8	134	50
— Large Reef, part dry.	8	18	134	41
— Southernmost, Angour	6	53	134	21
Matelotes, N. extr.	8	41	137	40
—— Southernmost	8	19	137	33
Yap or Hunter's Isl., N. p.	9	40		
—— S. p.	9	25	138	1
Philip Islands	8	6	140	52
Thirteen Islands, S.W. ex.	7	18	143	53
Haweis's Island	7	30	146	28
Strong's Island	5	12	162	58
Islands	5	28	153	24
Islands	5	47	157	42
Islands	6	9	160	51
Islands	6	17	159	12
Hope's Islands	5	15	165	9
Baring's Islands*	5	35	168	26
Teyoa Island	6	6	162	29
Providence Islands	9	34	160	58
Ditto	9	50		
Brown's Range,				
—— Arthur's Island, N.	11	40	162	15
—— Parry's Island, S.	11	19	162	25
Margaret's Island	8	52	166	15
Lydia's Island	9	4	165	58
Catharine's Island	9	14	166	2
Arrecife's Island	9	31	161	8
Mosquito group, low and dangerous	7	46	168	23
	8	10	168	00
Peterson's Island	8	54	166	35
Chatham Island, E. pt.	9	30	170	15
Reef	10	00	179	21
Calvert's Islands, S. extr.	8	30	171	11
Ibbetson's Islands	8	18	171	8
Elmore Islands, S. I.	7	15	168	45
Mulgrave's Islands, middle	6	16	171	55
Banham's Island,* E. pt.	6	01	169	48
Cook's Island	1	18	171	57
Hall's Island†	0	51	173	4
Reef	1	00	179	34
Pitt's Island,* N. pt.	3	20	172	57
Matthew's Island*	2	3	173	26
Simpson's Island	0	30	173	53
Macassgill's Islands	6	12	160	48
St. Bartholomew	15	10	163	53
Cornwallis or Smyth's Isles	16	50	169	40
Wake's Island*	19	17	166	32
Lamira, W. pt.	20	20	164	15
Gaspar Island	14	55	176	20
Gaspar Rico Island	14	42	169	3
Wake's Rocks	17	20	172	40
St. Peter	11	13	179	00 W
Barbadoes	8	54	178	00
Krusenstern's Rock	22	11	175	42
Necker Island†	23	34	164	43
French Frigate's Shoal†	23	45	165	59

* See Table on page 451. † See Table on page 450

TABLE LIV.

Latitudes and Longitudes.

	Place	Lat. D. M.	Long. D. M.
	Lisiansky's Island	26 3 N	173 40 W
Sandwich Islands.	Owhyhee, N. point*	20 23	155 54
	—— E. point	19 34	154 54
	—— S. point	18 54	155 49
	—— Karakakoa Bay	19 28	155 56
	Mowee, E. point*	20 47	156 7
	—— S. point	20 32	156 25
	—— W. point	20 54	156 48
	Tahoorowa	20 31	156 39
	Ranai, S. point	20 43	157 0
	Morotoi, W. point	21 6	157 24
	Woahoo* N. pt.	21 43	158 7
	Attoi, Whymoa Bay	21 57	159 42
	Tahoora	21 40	160 35
	Oneeheow	21 50	160 15
	Oreehoua	22 2	160 8
	Bird's Island*	23 5	161 49
	Gardner's Island, discovered 1820	25 8	168 09
	Maro's Reef, ditto	25 31	170 46
	Gallego Island	1 42	104 5
	Christmas or Noel Island	1 58	157 32
	Sidney or Fanning's Isl.	3 52	158 22
	Island	4 30	169 33
	New York Island*	4 42	160 13
	Cocoss Islands, or Chatham Bay	5 33	87 1
	Palmyra Island, S. pt.	5 48	162 23
	Island	6 41	166 2
	Barbary Island	8 55	178 00
	Reef	10 00	179 28
	Clipperton's low Island	10 28	109 19
	Manuel Rodriguez	10 57	153 45
	Island	11 33	164 00
	Island	13 4	168 35
	Shoal	13 32	170 26
	Shoal	14 42	170 23
	Cluster of Islands	16 00	133 00
		17 00	136 00
	Island	16 30	163 54
	Passion Rock	16 54	109 9
	Cornwallis Island	16 57	169 36
	New Blada	18 12	114 5
	Clarion Island	18 21	114 23
	Island	18 22	155 15
	Shoal	18 27	170 30
	Socora Island	18 48	110 56
	Wilson's I.	19 13	166 55
	St. Benedicto	19 18	110 45
	Freshwater	19 22	115 8
	Roca Partida	19 6	111 52
	Mallon Island	19 20	165 23
	Cloud's Island	19 43	114 57
	Copper Island	20 6	131 43
	Island	21 0	176 30
	Shovel Island	22 6	112 14
	Massachusetts Island	22 28	176 36
	Island	24 6	167 41
	Henderson Island	24 12	128 6
	—— another account	24 26	
	Gardner's Reef	25 8	168 9
	Polland's Island	24 52	168 20
	Allen's Reef	25 00	167 57
	Cooper's Island	25 43	131 35
	Maro's Reef W. pt.	25 31	170 46
	Island	22 31	131 0
	A Rock	25 30 N	174 3 W
	Laysan's Island	25 46	171 49
	Liscanskey's Island	26 03	173 41
	Neva Island	25 54	172 20
	Maro's Reef, N. pt. E.	25 19	170 32
	Island and Rock	26 24	170 54
	Pearl and Kermes group	27 43	175 48
	Clarke's Reef, 60 miles N. W. and S. E.	27 43	175 48
	Bunker's Hill	28 00	173 20
	Island	28 12	176 50
	Ocean I., N. pt	28 36	178 25
	A Bank	32 28	118 49
Gallapagos Islands.	Culpepper's Island	1 40	92 4
	Wenman's Island	1 23	91 53
	Redondo Rock	0 15	91 40
	Abington Island, Mid.	0 32	90 48
	Albemarle Island, N. pt.	0 09	91 25
	S. W. Point	1 00 S	91 32
	James I. Harbor	0 12	90 56
	Charles Island, S. p.	1 20	90 33
	Chatham Island, N. E. p.	0 45	89 19
	—— Stephen's Bay	0 53	89 37

XLIX. *Islands, Rocks, and Shoals, in the SOUTH PACIFIC OCEAN.*

	Place	Lat. D. M.	Long. D. M.
	New Guinea,		
	— Middleburg Island	0 20 S	132 9 E
	— Cape of Good Hope	0 20	132 31
	— Flat Point	0 46	134 25
	— Cape Valsche	8 22	137 40
	— Cape Rodney	10 15	148 30
	— King William's Cape	6 40	148 31
Torres Straits.	Torres or Endeavor Straits		
	Eastern Fields or Reefs, N. E. end	10 2	145 43
	— N. W. part	9 59	145 26
	Murray's Islands	9 56	144 3
	Wamvax or Darnley Isl.	9 35	143 49
	Pandora's Shoals, N. p.	9 55	144 14
	—— Wreck Reef, S. p.	11 25	144 00
	—— Portlock's Reef	9 48	144 45
	—— ent. Torres Straits	9 54	144 42
	—— Boot Reef	9 59	144 40
	Indefatigable's ent. ditto	11 50	144 10
	Halfway Island	10 7	143 19
	Booby Isle	10 37	141 56
	York Island West I.	9 45	143 27
	Prince of Wales's Is. S. pt.	10 46	142 12
	Kangaroo Coral Reef	13 22	143 47
	Providence Islands,		
	—— Little Providence or Danger Island	0 11	135 12
	—— N. W. ext. of Shoal off ditto	0 1	135 8
	Louisiade Isles,		
	—— Cape Deliverance	11 22	154 26
	Stephen's Island	0 21	137 48
	Durour's Island	1 34	143 12

Digitized by Google

* See Table on page 450.

TABLE LIV.

Latitudes and Longitudes.

	Lat. D.	Lat. M.	Long. D.	Long. M.
Solomon Islands.				
Admiralty Island, Is. N.	1	54 S	146	51 E
limits	2	24	148	10
Sydney Shoal	3	20	146	50
Active's First Reef, (discovered 1811,)	3	40	146	53
—— Second Reef, (do.)	3	41	146	37
New Ireland,				
— Cape St. George	4	51	152	55
— Carteret's Harbor	4	42	152	46
New Hanover, W. end	2	32	149	50
New Britain,				
— Cape Palliser	4	37	152	16
— Cape Orford	5	24	152	4
— Port Montague	6	10	150	30
— South Cape	6	30	149	48
Cocos Islands	4	40	156	50
Shoals W. of Bouganville's Strait	6	11	154	22
Bouganville's Strait	7	00	155	55
Laughlan's Islands, S. E. ext.	9	20	153	42
Bridgewater Shoal	8	54	157	12
Cape Deception	8	42	157	18
Cape Nepean	8	51	157	32
Cape Marsh	9	3	159	7
Deliverance, small Islands	10	51	162	27
Indispensable Strait, S. ent.	10	15	161	15
Bellona Island	11	12	159	54
Bellona Shoal	12	5	159	48
Pandora and Indispensable Shoal, N. p.	12	6	160	30
———— S. p.	12	46	160	42
Wells's Shoal	12	20	158	13
Port Praslin	7	26	158	20
Stewart's Island	8	27	163	00
Bradley's Shoal	6	52	161	06
Lord Howe's group	5	30	159	31
Hunter's Islands	4	48	157	00
Shank's Island	0	28	163	00
Blancy's Island	0	39	174	15
Dundas Island	0	15	173	58
Drummond's Island†	1	14	174	53
Byron's Island	1	18	177	45
Hope Island	2	23	176	59
St Augustine Island*	5	35	176	6
Sherson's Island	5	56	176	33
Ellice's group* N. W. one.	8	26	179	14
Mitchell's group, S. pt.	9	18	179	48
Plaskett's Island	9	18	179	50
Independence Island	10	25	179	00
Mitchell Island	10	27	179	22
Island	10	45	179	35
Onaseuse or Hunter's Isl.	15	31	176	11
De Peyster's Isl's.*N. one.	7	56	178	29
Ocean's High Island	0	48	170	49
Pleasant Island	0	25	167	20
Gardner's Island	1	00	168	40
Duff's group	10	00	166	50
Gangus' Island	9	44	166	43
Stewart's Island	8	24	163	00
Egmont or Santa Cruz Isl.				
—— Cape Byron	10	41	166	10
Pitt's or Alderney Island	11	50	166	46
Cherry Island	11	37	169	44
Volcano Island	10	23	165	49
Mitre Island	11	55	170	9
Barwell Island	12	21	168	48

	Lat. D.	Lat. M.	Long. D.	Long. M.
Pandora's Reef	12	11 S	172	7 E
Charlotte Bank	11	50	173	12
New Hebrides.				
Sir J. Banks's Island	13	27	167	24
Espiritu Santo, Cape Lisburne	15	41	166	44
—— Cape Cumberland	14	43	166	40
—— Bay St. Philip and St. James	15	10	167	5
—— Cape Quiros	14	56	167	5
Lepar's Island	15	23	167	54
Maskelyne's Island	16	32	167	59
Mallicolo, Cape Sandwich	16	28	167	59
———— Port Sandwich	16	25	167	46
St. Bartholomew's Island	15	42	167	17
Aurora Island, N. pt	14	56	168	6
Table Island	15	38	167	7
Whitsuntide Island	15	26	168	10
Ambrym Island, E. pt.	16	14	168	24
Paoom Island	16	26	168	29
Three Hills	17	4	168	19
Apae Island, N. pt.	16	36	168	10
Sheppard's Islands	16	58	168	42
Monument	17	0	168	35
Montague Island	17	26	168	17
Hinchingbroke Island	17	25	168	38
Sandwich Island, S. E. pt.	17	52	168	33
Erromango, Traitor's Head	18	46	169	15
Immer Island	19	21	169	31
Tanna, Port Resolution	19	32	169	29
Erronam	19	31	170	8
Enatum, W. pt.	20	10	169	42
Durand's Reef	22	6	169	2
Walpole Island*	22	27	169	7
Matthew's or Hunter's Island* Rock	22	27	172	10
New Caledonia.				
Diana's Bank, about	15	41	150	30
Bougainville's Reefs	15	35	148	00
	15	17	147	57
Alert's Reef	17	2	151	49
Mellish Reef, sand cay	17	25	155	53
Bampton Reef, N. pt.	19	01	158	27
Avon Island, S. W. islet	19	32	158	15
Chesterfield G. Loop Is*	19	59	158	30
—— N. W. point of reef	19	37	158	13
Bellona Reef, Booby R., N. W. Hn.	20	57	158	32
—— N. horn of N.W. Reef	20	48	158	28
Minerva's Shoal	20	50	159	23
	21	22	159	10
Baring's Shoals	20	40	158	40
	21	50	159	30
—— Sandy Island	21	24	158	34
Kenn Reef, N. pt.	21	06	155	46
Saumarez R., N.E. sand cay	21	38	153	47
Small, low, woody Island	18	3	162	51
Huon Island	18	11	162	52
Reef, about	19	00	162	52
—— N. W. p.	19	58	163	30
Balleabea Island	20	7	164	07
Pudyona, N. W. p.	20	6	164	7
Cape Colnett	20	30	164	44
Cape Coronation	22	2	167	47
Qu. Charlotte's Foreland	22	15	166	55
Isle of Pines	22	38	167	25

* See Table on page 451. † See Table on page 450.

Digitized by Google

TABLE LIV.

Latitudes and Longitudes.

	Lat. D.	Lat. M.	Long. D.	Long. M.
Botany Island	22	27 S	167	1 E
Prince of Wales's Fore-land, S. p.	22	30	166	50
Port St. Vincent	22	10	165	55
Loyalty Island	20	54	166	30
Wreck Reef, West cay	22	12	155	11
Cato's I. and Bank	23	15	155	34
Reef	23	40	160	14
Reef	23	48	164	14
Ray's Island	25	00	166	21
Reef	26	4	160	00
	26	12		
Sir C. Middleton's Island	28	13	160	31
Middleton's Shoals	29	20	158	53
Elizabeth Reef* N. E. pt.	29	34	159	24
Island	31	19	160	42
Lord Howe's Island	31	37	159	14
Norfolk Island, (Mt. Pitt,)	29	0	167	46
Rosavetta Reef	30	30	173	28
New Zealand.				
North Cape	34	24	173	1
Cape Bren	35	10	175	0
Cape Colville	36	28	175	20
Mercury Bay	36	48	175	43
Cape East	37	42	178	40
Tolaga Bay	38	22	178	26
Table Cape	39	6	178	7
Cape Kidnappers	39	41	177	9
Cape Turnagain	40	32	176	43
Banks's Island, E. end	43	46	173	14
Cape Saunders	45	53	170	50
Molineaux Harbor, N. pt.	46	25	169	55
The Snares, E. one.	48	3	166	45
Knight's Island	48	15	166	44
Cape South	47	17	167	32
South-west Bay	46	30	167	25
Solander's Island	46	32	166	54
West Cape	45	56	166	6
Dusky Bay, N. pt. en.	45	43	166	27
Open Bay	43	51	168	43
Cape Foulweather	41	46	171	30
Cape Farewell	40	31	172	47
Queen Charlotte's Sound	41	5	174	27
Cape Campoell	41	40	174	27
Cape Palliser	41	38	175	21
Cape Egmont	39	20	173	39
Gannet Island	37	57	174	32
Macquarie's Island* S.pt.	54	44	159	49
The Judge and his Clerk	54	55	159	10
The Bishop and his Clerk	55	15	158	56
Auckland's group*S.cape.	50	56	166	7
Campbell's Island	52	32	169	13
Bounty Islands	47	44	179	7
Antipodes Islands	49	35	179	2
Chatham Island, Cape Young	43	48	176	58W
Cornwallis Islands	44	36	175	27
Macauley Island	30	16	178	32
Sunday Island	29	12	178	13
Vasques	25	40	174	56
Nicholson's Shoals	23	59	178	20
	23	37	177	52
	20	6	168	36
Rotumah or Grenville's Island, E. Sum.	12	31	177	15 E

	Lat. D.	Lat. M.	Long. D.	Long. M.
Solitary Island	10	40 S	176	00W
Duke of Clarence's Island†	9	5	171	38
Duke of York's Island†	8	36	172	4
Quiros Island	10	40	170	00
Jesus Island	6	46	166	00
Letticus Island	11	48	162	00
Suwarrow's Islands	13	6	163	23
	13	20	163	31
Wallis Island†	13	24	176	9
Proby's Island	15	53	175	51
Gardner's Island	17	57	175	17
Keppel's Island	15	57	173	58
Friendly Islands.				
Boscawen's Island	15	54	173	48
Navigator's Islands,				
— Opoun, E. p.	14	9	169	2
— Leone, S. p.	14	8	169	16
— Tanfoue, W. p.	14	11	169	38
— Maoune, S. E. p.†	14	19	170	37
— Oyolava, S. E. p	14	3	171	21
— Otatuelah	14	30	170	41
Calinasse, N. p.	13	45	171	51
Islet Plat	13	51	171	48
Amargura	17	58	174	16
Vavaoo (Howe's) Island	18	39	174	00
Lati or Bickerton Island	18	49	174	35
Savage Island, S. pt.	19	10	169	50
Toofoa	19	46	175	3
Haanho	19	41	174	15
Bouhee	19	34	174	29
Annamoka	20	14	175	2
Hoonga-hapee	20	36	175	28
Tongataboo,				
— Van Dieman's Road	21	6	175	5
Eoaa, E. p.	21	24	174	57
Pylstaart's Island	22	22	176	04
[N.E.pt.				
Pearl and Herme's Reef.	27	48	175	36
King George's Reef	19	56	167	30
Palmerston Island	18	4	163	10
Whytootaeke	18	54	159	32
Hervey's Island	19	17	158	54
Wateoo Island	20	0	158	6
Maria Island	21	45	155	10
Mangea Island	21	57	158	0
Roxburgh Islands	21	36	159	40
Society Islands.				
Scilly Island	16	30	155	10
Lord Howe's Island	16	50	154	21
Maunura Island	16	26	152	12
Bolabola Island	16	32	151	46
Ulietea	16	45	151	31
— Ohameneno harbor.	16	45	151	35
Huaheine, Owharre Bay.	16	43	151	8
Sir C. Sanders's Island	17	29	150	58
Eimeo, (Taloo harbor,)	17	30	149	47
Tethuroa	17	1	149	27
Otaheite, Point Venus†	17	29	149	29
— Oaitipeha Bay	17	46	149	14
Osnaburg or Miatea	17	52	148	5
Prince of Wales Isl., N. p.	14	58	147	50
Palliser's Island	15	38	146	30
Chain Island	17	25	145	30
Duke of Gloucester Is. E.I.	20	42	[illegible]	8
Ohetiroa	22	34	150	13
Remitura Island	22	40	152	50
Toobouai	23	25	149	24
High Island	23	42	148	3

* See Table on page 451.

† See Table on page 454

Digitized by Google

TABLE LIV

Latitudes and Longitudes.

		Lat. D. M.	Long. D. M.
Dangerous Archipelago.	Byron's Islands,		
	—— Taoukaa Island.....	14 30 S	145 9 W
	Disappointment Islands*	14 4	141 22
	Adventure Island.......	17 3	144 14
	Furneaux Island........	17 3	143 7
	Resolution Island* S. E..	17 23	141 35
	Island.................	16 00	139 00
	Island.................	17 00	138 00
	Bird Island	17 49	143 7
	Bow Island	18 17	140 43
	Prince Henry's Island...	18 43	141 42
	Cumberland Island, S.E.pt	19 13	141 11
	Gloucester Island, N.E.pt	19 8	140 37
	Queen Charlotte's Island	19 18	138 42
	Whitsunday Island	19 26	138 36
	Lagoon Island..........	18 43	138 43
	Osnaburg Island, S. W. pt.	22 54	139 37
	Bligh's Lagoon Island...	21 38	140 38
	Carysfoot Island, N. E. pt.	20 45	138 22
	Lord Hood's Island	21 31	135 32
	Gambier's Island, mt. ...	23 8	134 55
	Crescent Island, S. pt....	23 20	134 35
	St Juan Baptista	24 26	135 6
	Pitcairn's Island........	25 4	130 8
	Oparo Island...........	27 36	144 11
Washington Islands.	Nukahiwa Isl., (Federal,)		
	— Port Tochitschagoff...	8 57	139 42
	— Port Anna Maria, ent.	8 57	140 6
	— Cape Martin, S. E. p..	8 57	139 32
	— S. point.............	8 59	139 44
	— N. W. point.........	8 53	139 49
	Uahuga Island, (Washington Island,) W. p.	8 58	139 33
	Uapoa Island, (Adams,).	9 21	140 6
	Level Island, (Lincoln,).	9 29	
	Mottauity Islands, (Franklin,).............	8 43	140 43
	Hiau Island, (Knox, Roberts,)...............	7 59	140 48
	Small sandy Island	7 57	140 30
	Fattuuhu Island, (Hancock,)...............	7 50	140 6
Marquesas.	Hood's Island..........	9 26	138 57
	Hiva-Oa, N. pt..........	9 34	139 4
	Ohitahoo, Resolution Bay	9 55	139 9
	Onateaya Island........	9 58	138 51
	Magdalena Island.......	10 27	138 49
	Bunker's Shoal.........	0 17	160 40
	Marcus Island..........	0 26	159 50
	Island.................	1 5	138 54
	Brock's Island..........	1 13	159 30
	Island.................	3 32	173 45
	Hero Island............	5 40	155 55
	Island.................	6 34	166 30
	A Rock................	7 51	139 54
	Pennryhn's Island, N. pt..	8 55	158 6
	Tienhoven Island.......	10 5	156 57
	Groningue Island	10 5	156 50
	Reirsen's Island	10 2	161 10
	Humphrey's Island	10 38	161 2
	A Reef.................	10 46	166 6
	Pescado Island	10 33	159 25
	Roggewein's Island.....	10 51	156 7
	Tiburone's Island	10 58	143 0

		Lat. D. M.	Long. D. M.
	Flint Islan *...........	11 26 S	151 46 W
	Bauman's Islands.......	11 52	155 12
	King George's Is.	14 22	144 58
	—— Tiokea, Oura......	14 44	145 20
	Isle des Chiens*........	14 50	138 47
	Isle Romanzoff.........	14 57	144 35
	Isles de Krusenstern, extending N. N. E. and S. S. W. 15 miles ..... centre	15 00	148 41
	Chaine du Rurick, N.E. p.	15 11	146 47
	— E. p................	15 20	146 30
	— W. p*	15 20	
	Dageraad Island........	15 45	146 56
	Dean, or Prince of Wales, or Oanna Island ..... *W. p.	15 05	147 59
	E. p.	15 17	147 14
	Island.................	16 00	139 00
	Island.................	17 00	138 00
	Island.................	20 00	167 50
	Elizabeth Island	21 6	178 36
	Eunice Island..........	21 8	178 47
	Armstrong's Island	21 21	161 4
	Anderson's Island, (or Elizabeth Island,) N.E.p.	24 22	128 19
	Ducie's Island, N.E. pt...	24 40	124 48
	Island.................	25 13	130 28
	St. Ambrose Island N. p.	26 20	80 00
	N. pt. of St. Felix......	26 17	80 21
	Gray's Island	26 24	92 24
	Sales y Gomez	26 28	105 26
	Easter Island, Peak.....	27 8	109 17
	Island.................	28 6	95 12
	Group of Islands	31 3	129 24
	Massafuera	33 45	80 47
	Juan Fernandez, S. W. p.	33 49	79 6
	—————— E. p....	33 41	78 53
New South Shetland.	NEW SOUTH SHETLAND.		
	Clarence Island, Floyd's Promontory..........	60 57	54 6
	—— Cape Bowles	61 20	54 8
	Cornwallis Island.......	61 04	54 28
	Seal Islands............	61 00	55 32
	Cape Valentine.........	61 3	54 40
	Sarah Island	61 22	55 30
	Obrien's Islands........	61 32	55 52
	Bridgeman's Islands	62 06	56 40
	Cape Melville..........	62 00	57 30
	Sheriff Cape	62 28	60 28
	Ditto, (another account,).........	62 21	61 47
	Yankee Straits	62 30	60 22
	Ragged Island	62 40	62 10
	Ditto, (another account,).........	62 42	62 20
	Ditto, the harbor, (by another person,)..	62 55	63 5
	New Plymouth.........	62 45	61 37
	Monroe's Island, President's Bay.........	62 46	62 20
	Castle Rock, (W. of Monroe's Island,)......	62 50	62 30
	Mount Pisgah.........	63 00	63 00
	Ditto, (another account,).........	62 57	63 40

* See Table on page 450

Digitized by Google

TABLE LV.

TIDE TABLE FOR THE COAST OF THE UNITED STATES.

[FROM THE UNITED STATES COAST SURVEY.]

ATLANTIC COAST.

Place.	Interval between Moon's Transit and High Water.		Rise and Fall.			Mean Duration of—		
	Mean Interval.	Diff. between greatest and least Interval.	Mean.	Springs.	Neaps.	Flood.	Ebb.	Stand.
Eastport to Long Island.	h. m.	h. m.	Feet.	Feet.	Ft.	h. m.	h. m.	h. m.
Eastport, Me.	11 8	0 51	18.1	20.6	15.4	6 3	6 23	
Hunniwell's Point, Kennebec River, Me.	11 15	1 14	8.1	9.3	7.0	6 16	6 11	0 22
Portland, Me.	11 25	0 44	8.9	9.9	7.6	6 14	6 12	0 20
Portsmouth, N. H.	11 23	0 53	8.6	9.9	7.2	6 22	6 7	0 21
Newburyport, Mass.	11 22	0 50	7.8	9.1	6.6	5 16	7 9	0 24
Rockport, Mass.	10 57	0 42	8.6	10.2	7.1	6 17	6 9	0 30
Salem, Mass.	11 13	0 50	9.2	10.6	7.6	6 19	6 6	0 6
Boston Light, Mass.	11 12	0 35	9.3	10.9	8.1	6 20	6 6	0 15
Boston, Mass.	11 27	0 43	10.0	11.3	8.5	6 13	6 13	0 9
Plymouth, Mass.	11 19	0 51	10.2	11.4	9.0	6 13	6 17	0 29
Wellfleet, Mass.	11 5	1 13	11.2	13.2	9.2	6 6	6 17	0 15
Provincetown, Mass.	11 22	0 40	9.2	10.8	7.7	6 16	6 10	0 21
Monomoy, Mass.	11 58	0 37	3.8	5.3	2.0	6 25	5 59	0 36
Nantucket, Mass.	12 24	0 37	3.1	3.6	2.6	6 23	5 44	0 9
Hyannis, Mass.	12 22	0 30	3.2	3.9	1.8	6 44	5 41	0 9
Edgartown, Mass.	12 16	0 34	2.0	2.5	1.6	6 51	5 29	0 24
Holmes's Hole, Mass.	11 43	0 31	1.7	1.8	1.3	6 41	5 21	0 12
Tarpaulin Cove, Mass.	8 4	0 49	2.3	2.8	1.8	6 9	6 17	0 34
Wood's Hole, Mass., (north side)	7 59	0 53	4.0	4.7	3.1	6 51	5 31	0 38
Wood's Hole, Mass., (south side)	8 34	0 45	1.6	2.0	1.2	5 17	7 10	0 59
Menemsha Bight, Mass.	7 45	1 0	2.7	3.9	1.8	6 14	6 14	0 4
Quick's Hole, Mass., (north side)	7 31	1 15	3.7	4.3	2.9	6 31	5 54	0 39
Quick's Hole, Mass., (south side)	7 36	1 10	3.1	3.8	2.3	6 29	5 55	0 40
Cuttyhunk, Mass.	7 40	0 49	3.5	4.2	2.9	6 31	5 54	0 39
Kettle Cove, Mass.	7 48	1 0	4.3	5.0	3.7	6 17	6 4	0 29
Bird Island Light, Mass.	7 59	0 45	4.4	5.3	3.5	6 51	5 58	
New Bedford entrance, (Dumpling Rock,) Mass.	7 57	0 41	3.8	4.6	2.8	6 50	5 53	0 42
Newport, R. I.	7 45	0 24	3.9	4.6	3.1	6 21	6 3	0 23
Point Judith, R. I.	7 32	0 46	3.1	3.7	2.6	6 12	6 10	1 0
Block Island, R. I.	7 36	0 41	2.8	3.5	2.0	6 23	6 2	0 5
Montauk Pt., Long Island, N. Y.	8 20	1 11	1.9	2.4	1.8	6 17	6 7	0 31
Long Island Sound.								
Watch Hill, R. I.	9 0	0 23	2.7	3.1	2.4	6 35	5 56	0 14
Stonington, Conn.	9 7	0 30	2.7	3.2	2.2	6 15	6 10	0 25
Little Gull Island, N. Y.	9 38	1 7	2.5	2.9	2.3	6 1	6 21	0 37
New London, Conn.	9 28	0 52	2.6	3.1	2.1	5 56	6 26	0 22
New Haven, Conn.	11 16	1 8	5.9	6.2	5.2	6 24	6 5	0 33
Bridgeport, Conn.	11 11	1 3	6.5	8.0	4.7	6 1	6 7	0 30
Oyster Bay, Long Island, N. Y. .	11 7	0 51	7.3	9.2	5.4	6 8	6 24	0 25
Sand's Point, Long Island, N. Y.	11 13	0 31	7.7	8.9	6.4	5 55	6 30	0 14
New Rochelle, N. Y.	11 22	0 32	7.6	8.6	6.6	5 51	6 35	0 12
Throg's Neck, N. Y.	11 20	0 39	7.3	9.2	6.1	5 50	6 33	0 43

Digitized by Google

TABLE LV.

TIDE TABLE FOR THE COAST OF THE UNITED STATES.

ATLANTIC COAST—Continued.

Place.	Interval between Moon's Transit and High Water.		Rise and Fall.			Mean Duration of—		
	Mean Interval.	Diff. between greatest and least Interval.	Mean.	Springs.	Neaps.	Flood.	Ebb.	Stand.
New York Bay and Hudson River.	h. m.	h. m.	Feet.	Feet.	Ft.	h. m.	h. m.	h. m.
Sandy Hook, N. Y.	7 29	0 47	4.8	5.6	4.0	6 10	6 15	0 21
New York, N. Y.	8 13	0 43	4.3	5.4	3.4	6 0	6 25	0 28
Dobb's Ferry, N. Y.	9 19	0 44	3.6	4.4	2.7	6 5	6 18	0 17
Tarrytown, N. Y.	9 57	0 58	3.5	4.0	2.7	6 6	6 20	0 43
Verplanck's Point, N. Y.	10 8	0 34	3.1	3.8	2.5	5 25	7 12	0 16
West Point, N. Y.	11 2	0 37	2.7	3.2	2.0	5 28	7 10	0 20
Poughkeepsie, N. Y.	12 34	0 54	3.2	3.9	2.4	5.41	6 44	0 22
Tivoli, N. Y.	1 24	0 51	4.0	4.6	3.2	5 40	6 54	0 25
Stuyvesant, N. Y.	3 23	0 48	3.8	4.4	3.0	5 18	7 2	0 31
Castleton, N. Y.	4 29	0 55	2.7	3.0	2.3	5 1	7 23	0 20
Greenbush, N. Y.	5 22	0 40	2.3	2.5	1.9	4 26	7 59	
Coast of New Jersey.								
Cold Spring Inlet, N. J.	7 32	0 51	4.4	5.4	3.6	6 8	6 18	0 19
Cape May Landing, N. J.	8 19	0 47	4.8	6.0	4.3	6 11	6 15	0 20
Delaware Bay and River.								
Delaware Breakwater, Del.	8 0	0 50	3.5	4.5	3.0	6 15	6 6	0 26
Higbee's, Cape May, N. J.	8 33	0 43	4.9	6.2	3.9	6 26	6 0	0 19
Egg Island Light, N. J.	9 4	0 51	6.0	7.0	5.1	5 52	6 27	0 36
Mahon's River, Del.	9 52	0 48	5.9	6.9	5.0	6 11	6 11	0 26
Newcastle, Del.	11 53	0 24	6.5	6.9	6.0	5 6	6 43	0 47
Philadelphia, Pa.	1 18	0 44	6.0	6.8	5.1	4 52	7 6	0 15
Chesapeake Bay and Tributaries.								
Old Point Comfort, Va.	8 46	0 52	2.5	3.0	2.0	6 1	6 25	0 14
Point Lookout, Md.	0 32	0 45	1.4	1.9	0.7	5 59	6 19	0 35
Annapolis, Md.	4 38	0 40	0.9	1.0	0.8	6 11	6 15	0 32
Bodkin Light, Md.	5 42	0 48	1.0	1.3	0.8	5 23	7 8	0 15
Baltimore, Md.	6 33	0 44	1.3	1.5	0.9	5 54	6 33	0 44
Washington, D. C.	7 44	0 52	3.0	3.4	2.6	5 37	6 49	
James River, (City Point,) Va.	2 11	1 .0	2.8	3.0	2.5	5 14	6 58	0 32
Richmond, Va.	4 28	1 6	2.9	3.4	2.3	4 53	7 31	0 35
Tappahannock, Va.	0 42	0 46	1.6	1.9	1.3	5 21	7 6	
Coasts of North and South Carolina, Georgia, and Florida.								
Hatteras Inlet, N. C.	7 4	0 57	2.0	2.2	1.8	6 7	6 7	0 50
Beaufort, N. C.	7 26	0 50	2.8	3.3	2.2	6 11	6 10	0 42
Bald Head, N. C.	7 26	0 34	4.3	5.0	3.4	6 18	6 17	0 31
Smithville, N. C.	7 19	0 38	4.5	5.5	3.8	6 1	6 26	0 26
Wilmington, N. C.	9 6	1 0	2.7	3.1	2.2	4 45	7 40	0 30
Georgetown entrance, S. C.	7 56	0 42	3.8	4.7	2.7	6 4	6 19	0 35
Bull's Island Bay, S. C.	7 16	0 57	4.8	5.7	3.7	6 20	6 6	0 30
Charleston, S. C., (Custom-house wharf.)	7 26	0 48	5.1	6.0	4.1	6 19	6 7	0 33
St. Helena Sound, S. C	7 8	1 0	5.9	7.4	4.4	6 13	6 12	0 23
Tybee Sound, Ga., (Fort Pulaski)	7 20	0 40	7.0	8.0	5.9	5 49	6 35	0 26

Digitized by Google

TIDE TABLE FOR THE COAST OF THE UNITED STATES.

ATLANTIC COAST—Continued.

Place.	Interval between Moon's Transit and High Water.		Rise and Fall.			Mean Duration of—		
	Mean Interval.	Diff. between greatest and least Interval.	Mean.	Springs.	Neaps.	Flood.	Ebb.	Stand.
Coasts of North and South Carolina, Georgia, and Florida—Cont'd.	h. m.	h. m.	Feet.	Feet.	Ft.	h. m.	h. m.	h. m.
Savannah, Ga., (Dry-dock wharf)	8 13	0 51	6.5	7.6	5.5	5 4	7 22	0.14
Doboy Light-house, Ga.	7 33	0 55	6.6	7.8	5.4	6 2	6 20	
St. Simons, Ga.	7 43	0 46	6.8	8.2	5.4	6 10	6 16	0 20
Fort Clinch, Fla.	7 53	1 6	5.9	6.7	5.3	6 9	6 17	
St. John's River, Fla.	7 28	0 48	4.5	5.5	3.7	5 58	6 28	0 16
St. Augustine, Fla.	8 21	0 43	4.2	4.9	3.6	6 5	6 11	0 32
Cape Florida, Fla.	8 34	0 51	1.5	1.8	1.2	6 0	6 26	0 45
Indian Key, Fla.	8 23	0 49	1.8	2.2	1.3	6 25	5 59	0 19
Sand Key, Fla.	8 40	. .	1.2	2.0	0.6	6 31	5 55	0 13
Key West, Fla.	9 30	1 15	1.3	1.5	0.9	6 55	5 29	0 12
Tortugas, Fla.	9 56	1 32	1.2	1.5	0.6	6 43	5 40	
Gulf Coast of the United States.								
Charlotte Harbor, Fla.	0 43	1 38	1.1	1.3	0.8	6 51	5 35	
Tampa Bay, (Egmont Key,) Fla.	11 21	1 33	1.4	1.8	1.0	6 36	6 11	0 43
Cedar Keys, (Depot Key,) Fla.	0 49	1 55	2.6	3.2	1.6	6 12	6 13	
St. Mark's, Fla.	1 12	2 0	2.2	2.9	1.4	6 12	6 11	

The tides of ports in the Gulf of Mexico, west of Cape St. George, ebb and flow, as a rule, but once in twenty-four hours, or are single-day tides. At particular parts of the month there are two small tides in the twenty-four hours. The rise and fall in all these ports is small. The highest high and the lowest low waters occur when the greatest declination of the moon happens at full or change; the least tide when the moon's declination is nothing at the first or last quarter. The rise and fall being so small, the times and heights are both much influenced by the winds, and are thus rendered quite irregular. The following table gives the rise and fall at several points:

Rise and Fall at several Stations in the Gulf of Mexico.

Stations.	Mean Rise and Fall of Tides.		
	Mean.	At Moon's greatest Declination.	At Moon's least Declination.
	Feet.	Feet.	Feet.
St. George's Island, Fla.	1.1	1.8	0.6
Pensacola, Fla.	1.0	1.5	0.4
Fort Morgan, Mobile Bay, Ala.	1.0	1.5	0.4
Cat Island, Miss.	1.3	1.9	0.6
Southwest Pass, La.	1.1	1.4	0.5
Isle Dernière, La.	1.4	2.2	0.7
Entrance to Lake Calcasieu, La.	1.9	2.4	1.7
Galveston, Tex.	1.1	1.6	0.8
Aransas Pass. Tex.	1.1	1.8	0.6
Brazos Santiago, Tex.	0.9	1.2	0.5

Digitized by Google

TABLE LV.

TIDE TABLE FOR THE COAST OF THE UNITED STATES.

PACIFIC COAST.

Place.	Interval between Moon's Transit and High Water. Mean Interval.	Interval between Moon's Transit and High Water. Diff. between greatest and least Interval.	Rise and Fall. Mean.	Rise and Fall. Springs.	Rise and Fall. Neaps.	Mean Duration of— Flood.	Mean Duration of— Ebb.	Mean Duration of— Stand.
	h. m.	h. m.	Feet.	Feet.	Ft.	h. m.	h. m.	h. m.
San Diego, Cal.	9 38	1 35	3.7	5.0	2.3	6 22	6 0	0 30
San Pedro, Cal.	9 39	1 48	3.7	4.7	2.2	6 18	6 5	0 30
Cuyler's Harbor, Cal.	9 25	1 2	3.7	5.1	2.8	6 13	6 5	
San Luis Obispo, Cal.	10 8	1 52	3.6	4.8	2.4	6 25	5 58	
Monterey, Cal.	10 22	0 49	3.4	4.3	2.5	6 31	6 2	0 35
South Farallon, Cal.	10 37	1 16	3.6	4.4	2.8	6 18	6 9	
San Francisco, Cal., (north beach)	12 6	1 4	3.6	4.3	2.8	6 39	5 51	0 34
Mare Island, Cal.	1 14	1 15	4.8	5.2	4.1	6 13	6 7	
Benicia, Cal.	1 44	1 0	4.5	5.1	3.7	6 26	5 59	
Ravenswood, Cal.	0 10	0 57	6.3	7.3	4.9	6 15	6 11	
Bodega, Cal.	11 17	1 54	3.6	4.7	2.7	6 19	5 59	
Humboldt Bay, Cal.	12 2	1 11	4.4	5.5	3.5	6 19	6 0	
Port Orford, Oregon	11 26	1 6	5.1	6.8	3.7	6 19	6 7	0 39
Astoria, Oregon	0 16	1 13	6.1	7.4	4.6	6 3	6 28	0 33
Nee-ah Harbor, Wash.	0 7	1 28	5.6	7.4	4.8	6 20	6 6	
Port Townshend, Wash.	3 49	1 3	4.6	5.5	4.0	6 34	5 52	
Steilacoom, Wash.	4 46	1 6	9.2	11.1	7.2	6 3	6 25	0 28
Semiahmoo Bay, Wash.	4 50	1 2	5.7	6.6	4.8	6 11	6 19	0 26

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS,

ARRANGED ALPHABETICALLY,

WITH THE RISE OF THE TIDE AT SPRINGS AND NEAPS.*

[When a query, thus ?, is placed after the Time of High Water and the Rise, it indicates that what are given are approximations.]

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Abaco, Bahamas	8 0	3	
Abbey Head, Scotland	11 10	23	17
Abd-ul Kuri, Indian Ocean	8 30	6	
Aberdeen, Scotland	1 0	12	10
Aberdovey, Wales	8 0	15	
Abervrach, France	4 14	22	16
Aberystwyth, Wales	7 31	13½	10
Abrolhos, Brazil	3 20	6–7	
Abtao, Port, Chile	1 18	16–18	
Abú-shehr, Persian Gulf	7 30	7	
Acajutla, Central America	2 25	9	
Acapulco, Mexico, West coast	3 6	1½	
Acheen Head, Sumatra	8 45	8	
Achillbeg, Ireland	5 14	10½	8
Adam Bay, Australia, North coast	6 0	18	
Adams, Port, (Mary Island,) Yellow Sea	2 0	10	
Adelaide, Port, Australia, South coast	4 40	8	5–5½
Aden and adjacent Bays, Arabia, Southeast coast	7 30 to 9 30	7	4½
Adenara, Flores, Malay Archipelago	. .	8	
Admiralty Gulf, Australia, Northwest coast	Noon		
Adolphus Island, Australia, Northwest coast	7 30	21	
Adou Atoll, Maldives	1 0	4	
Adou Matte Atoll, Maldives	3 0	4	
Adventure Cove, Tierra del Fuego	3 10	4	
Adventure, Port, New Zealand	0 20	8	6
Adventure Sound, Falkland Islands	5 30	5½	
Agadir, or Santa Cruz, Africa	0 45	9	
Aggerminde, Jutland	4 9	2	
Agnes, St., Scilly Isles	4 30	16	
Agulhas, Cape, Africa, South coast	2 50	5	
Aillik Bay, Labrador	. .	7	
Ailu, Kapenuir Island, Marshall Islands	4 53	8	
Air Point, River Dee, England	10 54	25	19
Aix, Ile d', Charente River, France	3 20	17	12½
Ajár, Hindoostan, West coast	0 50	14	11
Akaroa Harbor, New Zealand	3 24	8	6
Akishi Bay, Japan	4 30	5	
Akyab, Aracan River, Bay of Bengal	9 45	9	6
Al Bidá, Persian Gulf	8 30?	6?	
Alabat Harbor, Luzon	10 0	9	
Alan Island, Patagonia, West coast	0 31	18	
Albany Islands, (Port Albany,) Australia, East coast.	0 15	10	7
Albemarle Island, Galapagos Islands	2 0	6	
Albemarle, Port, Falkland Islands	7 15	7	
Albert River, (Kangaroo Point,) Australia, North coast.	7 30	10–13	3–8
Alcmène Port, Isle of Pines, New Caledonia	8 6	4	

* By the Rise of the Tide is meant its vertical rise above the mean low water level of Spring Tides.

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Aldabra Islands, Mozambique	5 0	10	
Aldborough, England	10 45	8?	6½?
Alderney, English Channel	6 46	17	12¾
Alert Bay, Cormorant Island, Johnstone Strait, Vancouver Island.	. .	15	
Alexander, Port, Africa, Southwest coast	3 0	5	
Alfred, Port, Kowie River, Africa, South coast	3 50	4–5	3
Algeçiras, Spain	1 49	4	2½
Algoa Bay, Africa, South coast	4 0	4	5
Alligator Bay, Flores	. .	6	
Alligator River, Australia, North coast	8 15	15	
Alloa, Firth of Forth, Scotland	3 18	17½	15
Altona, Germany	5 9	8	
Amboyna, Moluccas	0 33	7	
Ameland, Netherlands	9 30	6½	
Amet Sound, Nova Scotia	10 30	8	5
Amirantó Isles, (St. Joseph Island,) Indian Ocean	5 0	8½	
Amlwch, Wales	10 30	18?	13?
Amoy, (Inner Harbor,) China, East coast	Noon	18½	14½
Amoy, Chiang Chiu, West River	3 40		
Ampanam Bay, Lombock	8 0	6	
Amrum, Denmark	0 30	9	
Amsterdam, Indian Ocean	11 0	3	
Armstrong Channel, Bass Strait	8 30	3	
Amulgawein, Persian Gulf	11 40	6	
Amur Strait, Gulf of Tartary	11 40	5–6	
Ananga, Japan	0 27	2–4	4½
Andaman Islands, Port Blair, Indian Ocean	9 30	7½	
Andaman Islands, Port Cornwallis	10 0	8¾	
Andaman Strait, Indian Ocean	10 24	9½	
Andrava Bay, Madagascar	3 30	7	
Andres, San, Bay, Patagonia, West coast	0 45	5	
Andrews, St., New Brunswick	10 50	25	21
Anegada, Virgin Islands	9 0	1½	
Aneiteum, (Port Inyang.) South Pacific	6 35	4	
Angosto, Port, Strait of Magellan	0 40	4	
Angoxa River, Africa, East coast	. .	13	
Angra, Azores	0 32	4½	
Angra, Pequena, Africa, Southwest coast	2 30	8	
Angria Bank, Hindoostan, West coast	10 30	9	
Anna Pink Bay, Patagonia, West coast	0 45	5	
Annan Foot, Scotland	11 56	20	14
Anne, St., Bay, Cape Breton	8 34	6	4½
Anno Bom Island, Africa	3 45	5	
Anthony Strait, Newfoundland	7 10	5	2¾
Anticosti Island, Gulf St. Lawrence, East Cape	1 0	5	3
Anticosti Island, Bear Bay	1 10	5	3
Anticosti Island, West Point	2 0	6	4
Antigonish Harbor, River St. Lawrence	9 0	4	2
Antigua Island, (English Harbor,) Caribbean Sea	. .	2	
Antongil Bay, (Port Choiseul,) Madagascar	4 0	5	
Antonio, Cape St., Cuba	. .	1½	
Antonio River, Africa, East coast	3 15	13	10
Antonio, Port St., Patagonia, East coast	10 45	18–30	
Antonio, Port St., Magellan Strait	Noon	7	
Antonio, San, Rio Plata	10 0	5½	
Antrobus Island, Gulf of St. Lawrence	10 30	5	3

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Antwerp, Belgium	4 25	15	
Aor Pulo, Sumatra, Northeast coast	. .	5	
Aotea Harbor, New Zealand	10 0	12	9½
Apamama, Gilbert Islands	4 30	6–0	
Appeetetat Bay, Gulf of St. Lawrence	11 10	5?	3?
Appin, Port, (Loch Linnhe,) Scotland	5 26	12½	8½
Appledore, England	5 28	23	16½
Aquin Bay, St. Domingo	Irregular	2–3?	
Aracan River, (Bar,) Bay of Bengal, East coast	9 45	9	6
Aracati, Brazil	6 0	8	6
Araish, El, Africa, North coast	1 30	9–12	
Arasaig, Scotland	5 50	13½	10
Arauco Bay, Chile	10 15	6	
Arbroath, Scotland	1 35	14	11
Arcachon, France	4 37	11½	9½
Arcas Rocks, Gulf of Mexico	Noon	1½	
Ardglass, Ireland	11 0	16	12
Ardintallan, (Loch Feochan,) Scotland	5 31	9	6½
Ardrishaig, Loch Fyne	11 53	9	7½
Ardrossan, Scotland	11 45	10	8
Arenas, Point, San Carlos, Patagonia, West coast	0 14	6	
Argyle, Bay of Fundy	9 27	12½	10½
Arica Road, Peru	8 0	5	
Arichat, Nova Scotia	8 10	5	4
Arinagour, Coll Island, Scotland, West coast	5 39	12½	9½
Arkhangel, White Sea	7 28	2½	
Arklow, Ireland	8 45	4	3
Arnhem Bay, Australia, North coast	8 10	6	
Arroa, Malacca Strait	. .	10	
Arthur, Port, Tasmania	7 52	4	
Arundel, England	0 25		
Arundel, (Bar)	11 35	16	11½
Asaph, St., Bay, Australia, North coast	5 45	14	
Ascension Island, South Atlantic	5 30	2	
Ashrafi Islands, Red Sea	6 0	1½	
Askaig, Port, Islay	4 58	6½	4
Assar Point, Hindoostan, West coast	Noon	12	8
Atacames Bay, Ecuador	3 37	13	
Athline, Loch Seaforth	6 16	15	10
Atico Road, Peru	8 53	5	
Atkesi, Yezo Island	10 0?		
Auckland Harbor, New Zealand, North Island	7 5	11	9
Auckland Island, South Pacific, (Port Ross)	Noon	3	
Augustine, St., Bay, Madagascar, West coast	4 30	13	
Aulapolay, Hindoostan, West coast	2 0	3	1–2
Aulezavik Sound, Labrador	. .	5	
Aux Cayes Bay, St. Domingo	Irregular	2–3?	
Avatcha Bay, Kamchatcha	3 30	6½	4½
Avon Isles, Australia, East coast	8 30	5	
Avon River, Bigbury Bay, England	5 47	16½	11½
Awasima, (Inland Sea,) Japan	0 7	10½	6?
Awanui River, New Zealand	7 44	7	
Axim, Africa, West coast	4 30	4	
Aylen Bay, Yellow Sea	2 30	6	4
Aymaun, Persian Gulf	11 20	6	
Ayr, Scotland	11 50	8½	7½
Ayr, Point of, Isle of Man	11 7	20?	16?

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Bab-el-Mandeb, Gulf of Aden	Noon	7	5½
Babel Island, Bass Strait	10 5	7	
Bachelor River, Magellan Strait	1 40	5	
Bacuit Bay, China Sea, East coast	10 0	6	
Badas Island, Linga Bay, Sumatra	6 0	12	
Badong Bay, Baly, South coast	11 0	9½	
Bahia, Brazil	4 26	8	
Bahreïn, Persian Gulf	5 30	7	
Balabac Island, China Sea, East coast	11 0	5	
Balad Harbor, New Caledonia	6 15	4½	
Balambangan Island, Borneo, North coast	10 0	6–8	
Balasore River, Bay of Bengal, West coast	10 0	15	
Balbriggan, Ireland	10 40	13	
Ballachulish, (Loch Leven,) Scotland	5 43	11	
Ballinacourty, Dungarvan, Ireland	5 12	12½	9½
Ballinskellig Bay, Ireland	3 40	12	7½
Ballycastle Bay, Ireland	6 25	3	2
Ballycottin, Ireland	4 54	12	9½
Ballycrovane, Kenmare River, Ireland	3 42	10½	7¾
Ballynakill Bay, Ireland	4 40	12½	9½
Ballyness, (Bar,) Ireland	5 22	11½	8½
Ballysadare, (Quay,) Ireland	6 0	8¾	5¾
Ballyshannon, (Bar,) Ireland	5 18	11½	8½
Ballyweel, Ireland	5 23	12½	8
Balta, Scotland	9 45	6	4½
Baltimore, Ireland	4 23	10½	8½
Baltrum, Germany	11 20	8	
Banana Islands, Africa, West coast	8 15	9	
Bankot or Sitri River, (entrance,) Hindoostan, West coast.	10 30	11	6
Banda, Moluccas	4 0	6?	
Bander Alúleh, Gulf of Aden	6 45	6	
Bander Gorí, Gulf of Aden	8 45		
Bander Jisseh, Persian Gulf	11 0	5	
Bander Khairan, Persian Gulf	11 0	5	
Bander Shúab, Indian Ocean	7 0	7	
Bander Feïkam, Arabia, Southeast coast	10 0	8½	
Banff, Scotland	0 28	10½	8
Bangkok River, Siam	Irregular	7½–11	8½–9
Banjoewangie, Java	1 0	9	
Banoko, Africa, West coast	5 24	5	
Bantam, Java	. .	5	
Bantry Harbor, Ireland	3 47	10	7½
Baracoa, Cuba	7 23	2½	
Barbados, Caribbee Islands	3 0	3	1½
Barbara, Port, Patagonia, West coast	0 28	6	4
Barbara, Santa, Island, California	8 0	3½	
Barbe, St., Harbor, Newfoundland	10 0	4	3
Barbe, St., Sumatra, Northeast coast	6 0	6	
Barbe, Santa, Island, California	8 0	3½	
Barclay Sound, Island Harbor, Vancouver Isl'd	Noon	12	
Barclay Sound, Uchucklesit Harbor, Vancouver Island.	. .	12	
Barclay Sound, Stamp Harbor, Vancouver Isl'd	Noon	12	
Bardsey Island, Wales	7 40	15	
Barfleur, France	8 51	17	13½
Barmouth, Wales	7 41	17	13½

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Barnstaple Bridge, England	6 28	10½	7½
Barquero, (entrance,) Spain, North coast	3 15	10¾	
Barra Island, (North Harbor,) Scotland, West coast.	5 48	11½	8½
Barra Castle Bay, Scotland, West coast	5 44	11¾	8½
Barra Head, Bernerad Island, Scotland, West coast.	5 45	11½	7
Barracouta Harbor, Gulf of Tartary	10 0	3½	
Barragan Bay, Rio de la Plata	7 0	5–9	
Barren Island, China Sea, East coast	9 30	5¾	
Barren Islands, Madagascar	4 45	12	
Barrow Harbor, Newfoundland	6 13	4½	2½
Barrow, Point, Arctic Regions	11 45	½–¾	
Barry Island, Wales	6 39	35½	26
Barton, Port, (Bubon Point,) China Sea, East coast.	10 55	6	
Bas, Ile de, France	4 49	23	17
Básidúh, Persian Gulf	Noon	10	
Basil Bay, Korea, West coast	4 15	18	10
Basque Port, Newfoundland	8 55	5½	3
Basrah, (Bar,) Persian Gulf	Noon		
Basrah, Town	6 0?	9?	
Bassein River, Bay of Bengal	10 0	9	6
Batanes, Bashee Islands, China Sea, East coast	. .	4	
Batavia, Java	10 0	2	
Batchian, Gilolo, Moluccas	1 0	6	
Bate, (Gulf of Kutch,) Hindoostan, West coast	0 20	12	10
Bateman Bay, Australia, East coast	8 0	4–6	
Bathurst, Gulf of St. Lawrence	3 15	7	4
Bathz, Netherlands	3 15	14	
Batiscan, River St. Lawrence	9 48	3½	2
Batoo Barra, Sumatra	2 50	7–10	
Batticalao River, Ceylon	5 0	2–3	
Bawdsey Haven. (See Woodbridge Haven.)			
Bay of Harbors, Bull Road, Falkland Islands	6 0	5	
Bay of Islands, (Motu Mea Islet,) New Zealand.	7 15	9	6
Bay of Mercy, Banks Land	. .	2	
Bayonne, (Bar,) France	3 45	12	10
Bazaruto, Cape, Africa, East coast	4 15	10	
Beachy Head, England	11 20	20	15
Beagle Bay, Australia, West coast	11 30	13–15	
Bear, Cape, Prince Edward Island	9 0	6	3
Bear Head, Cape Breton Island	8 30	4½	3
Beatrice Islet, Australia, North coast	3 0	8	
Beaubère Island, Gulf of St. Lawrence	6 30	6	4
Beaulieu, England	10 25 0 15	10	8½
Beaumaris, Wales	10 32	21½	16½
Beaver Cove, Vancouver Island	. .	15	
Beaver Creek, Loughborough Inlet, British Columbia.	3 0	16	11½
Beaver Harbor, Vancouver Island	0 30	15¾	
Beaver Harbor, Nova Scotia	7 40	6½	4½
Bedeque Harbor, Prince Edward Island	10 15	7	5
Bedford Bay, Tierra del Fuego	0 30	7½	
Behring Bay, America, Northwest coast	0 30	9	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise. Springs.	Rise. Neaps.
	h.	m.	Feet.	Feet.
Belfast, Ireland	10	43	9½	8
Belgrano, Port, La Plata	6	0	12	10
Bell Sound, Spitzbergen	8	56	3½	
Belles Amour Bay, Labrador	9	0	4½	2½
Belligam Bay, Ceylon	2	20	2½	
Bellona Reefs, (Middle,) Australia, East coast	8	30	6	
Bembatooka Bay, Madagascar, West coast	4	30	16	
Bembridge Point, England	11	0	14	10½
Benbecula, Scotland	6	3	11½	8½
Bencoolen, Sumatra	6	0	3–5	
Benevente, Brazil	3	0	5	
Benguela, Africa, West coast	3	45	5–6	
Benin River, Africa, South coast	4	30	7	
Berbereh or Burburra, (Gulf of Aden,) Africa, East coast.	7	15	9	
Berbice, Guayana	4	30	8–10	6
Bergen, Norway	1	30	4	
Berkeley Sound, Falkland Islands	5	0	7	
Bermuda, Ireland Island, North Atlantic	7	14	4	
Bernera, Loch Roag, Lewis Island	6	11	11	8
Berneray Island, Sound of Harris	6	11	13	9½
Bersiap Point, Banka Strait	6	30	12	
Bersimis River, Gulf of St. Lawrence	2	0	12	7
Berwick, Scotland	2	18	15	11½
Betcheween Harbor, Gulf of St. Lawrence	11	32	5	3
Beypore River, (entrance,) Hindoostan, West coast.	0	15	4	3½
Bhowliaree Creek, Hindoostan, West coast	4	46	30	23
Bias Bay, (Tooniang Island,) China, East coast	8	0		
Bias Bay, (Tsangchow Island,) China, East coast	8	30		
Bic Island, Gulf of St. Lawrence	2	15	14	8½
Biddah River, Bay of Bengal, West coast	10	0	14	12
Bideford, England	6	7	16	
Bijouga Islands, Arcas Channel, Africa, West coast.	10	10	11–14	9
Bijouga Islands, Bissao, Africa, West coast	11	0	8	
Bijouga Islands, Orango Channel, Africa, West coast.	10	0	11	
Bilbao, (Bar,) Spain	3	0	13	
Bilbao, (Town,) Spain	3	20	9	
Bima Bay, Sumbawa	Noon		6	
Binkang Bay, China Sea, West coast	11	30	5	
Binnic, France	6	3	30	22½
Bintula River, China Sea, East coast	5	45	6	
Bird Island, Carlandagan Islands, China Sea, East coast.	9	30	6	
Bird Islands, Africa, South coast	4	0	4–5	
Blaavands Huk, Jutland	1	45	7	
Black Ball Harbor, Ireland	3	40	9½	7½
Black Rock, Bay of Fundy	11	29	36	31
Black Point, Australia, South coast	4	37	8	5–6
Black Point Bay, Africa, West coast	4	30	6	
Blacksod Bay, (Quay,) Ireland	4	47	10	8½
Blacktoft, River Humber	6	59	16	
Blair Harbor, China Sea, West coast	8	50	9	
Blakeney, England	.	.	9	
Blakeney, (Bar,) England	6	30	15	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Blanche, Port, Streaky Bay, Australia, South coast.	1 0	5	
Blankenberg, Belgium	0 15	13	10
Blanco, Cape, Africa, West coast	11 46	6	
Blas, San, Mexico, West coast	9 41	6½	
Blas, San, La Plata	2 0	12	10
Blasket Islands, Ireland	3 30	11½	8
Blauort Sand, Germany	0 38	12	
Blewfields, Mosquito Coast	1 50	2	
Bligh Sound, New Zealand	10 45	8	6
Blind Bay, Nova Scotia	7 46	7½	6
Bluff Cay, Bahamas	7 0	4½	
Bluff Harbor, New Zealand	1 18	8	6
Blunden Harbor, British Columbia	Noon	16	11½
Blyth, England	3 15	15	11
Blyth River, Southwold, England	10 20	6½	4½
Boca de Varadero, Cuba	8 39	2	
Boca Grande, Trinidad, Caribbee Islands	3 30	4	2½
Boca Mono, Trinidad, Caribbee Islands	3 50	4	2½
Boddam Cove, Ladrone Islands	9 40	4½	
Boerong Island, China Sea	4 45	7	
Bojador, Cape, Africa	Noon	8?	
Bolt Head, England	5 45	15?	11?
Bombay Dockyard, Hindoostan, West coast	11 40	12–17	
Bonacca Island, Bay of Honduras	9 0	1½	
Bonavista, Newfoundland	7 25	3½	2½
Bonne Esperance Harbor, Gulf of St. Lawrence	9 15	5	2½
Bonny River, Africa, West coast	4 50	6	5
Booby Island, Australia, North coast	4 30	8	
Bordeaux, France	6 50	14	12¾
Boria Bay, Hindoostan, West coast	10 0	10	8
Borja Bay, Magellan Strait	1 30	6	
Borkum, West Germany	10 43	7	
Borkum, East Germany	10 57	7	
Boscastle, England	5 15	22	17
Boston, (Sluice,) England	7 0	13	
Boston, (Deep Clay Hole,) England	. .	23½	
Boston, Hob Hole, England	. .	17	
Botany Bay, Australia, East coast	8 10	7–8	
Boteler River, Madagascar	4 30?	15?	
Boucaut, France	3 39	8¾	6
Boughton Harbor, Prince Edward Island	8 40	5	2½
Boulogne, France	11 25	25	19½
Bourbon Island, Indian Ocean. (See Reunion Island.)			
Bouro, (Cajili Bay,) Moluccas	1 32	4½	
Bow Island, South Pacific	2 40	3	
Bowen, Port, Australia, East coast	9 35	16	
Bowling, River Clyde, Scotland	0 39	9	
Boyanna Bay, Madagascar, West coast	4 30	15	
Bradore Bay, Labrador	8 45	4	2
Braha Harbor, Newfoundland	7 0?	2–3?	
Bramble Cay, Torres Strait	9 15	12	
Brandy Pots, River St. Lawrence	3 0	17	10
Brass River, Africa	4 0	6	
Brava, Africa, East coast	4 30	8	
Bray Head, Ireland	10 45	12	9½

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise.	
			Springs.	Neaps.
	h.	m.	Feet.	Feet.
Breaksea Sound, New Zealand	11	15	8	4
Bréhat, France	5	51	31	23½
Bremerhaven, Germany	1	40	11	
Brest, France	3	47	19	13¾
Bridgewater, England	8	0	18	
Bridgewater Bar, England	6	50	35	26½
Bridlington, England	4	39	16	12
Bridport, England	6	5	11½	7¾
Brielle, Netherlands	3	0	5	
Brig Bay, Newfoundland	9	46	5?	
Brighton, England	11	15	19¾	16
Brisbane, (Bar,) Australia	9	22	6½	4¾
Bristol, (King Road,) England	7	13	40	31
Bristol, Cumberland Dock Gates	7	13	31½	
Britannia Bay, Sumbawa	1	0	11–12	
British Sound, Madagascar, East coast	4	0	9½	
Broad Sound, Australia, East coast	11	0	20–30	
Broadhaven Harbor, Ireland	5	0	10½	7½
Broadway River, (entrance,) China, East coast	11	0	7½	
Broken Bay, Australia, East coast	8	30	5–7	
Broom Loch, (Ullapool)	6	40	14½	10½
Broughty Ferry, Scotland	2	22	14½	11
Brouwershaven, Netherlands	2	0	10	8
Brouwershaven-gat	1	0	9½	7½
Bruinisse, Netherlands	2	30	11	
Bruit River, Borneo	3	0	11	
Bruni River, China Sea, East coast	11	0	12	
Brunsbuttel, Germany	1	58	9	
Brunswick Bay, Australia, Northwest coast	Noon		24	
Brush, Yarmouth, England	.	.	5¾	4½
Bubon Point, Port Barton, China Sea, East coast	10	55	6	
Buctouche River, Gulf of St. Lawrence	3	30?	4?	2½?
Budehaven, England	5	45	23	17
Buenaventura, Port, Central America, (Negrilla Reef.)	4	0	13	
Buenaventura, Port, Cen. America, (off the town)	6	0	13	
Buenos Ayres, South America, East coast	Noon		3–5	
Buffalo River, (East London,) Africa, South coast	3	43	5	3½
Bulama Island, (Arcas Channel,) Africa, W. coast	10	10	14	11
Bull Harbor, Goletas Channel, Vancouver Isl'd	0	30	12½	
Bull Island, Newfoundland	7	22	3½	2
Bull's Mouth, (Achill Sound, North entrance,) Ireland.	5	38	10¾	7½
Bulsar Khar, Hindoostan, West coast	1	45	18	14½
Buluagan, O'sta Ana, Port, Filipinas	Noon		5½	
Bunawe, (Loch Etive,) Scotland	7	54	5¾	
Buncranna, Ireland	5	40	16	
Bunessan, Scotland	5	24	12	8½
Burburra. (See Berbereh.)				
Burin Harbor, Newfoundland	8	45	6½	4½
Burntisland, Firth of Forth, Scotland	2	24	16½	12¾
Burnt Isles, Kyles of Bute, Scotland	11	50	10	8
Burong Island, China Sea	4	45	7	
Burrard Inlet, Gulf of Georgia, British Columbia	6	0	16	
Burry Port, Wales	6	1	25½	18½
Busainga, Burias Island	0	30	6	
Bushire. (See Abû-shehr.)				

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Bussorah River, (Bar,) Persian Gulf	Noon		
Busuanga, China Sea, East coast	0 30	6	
Büsum, Germany	1 21	12	
Button Islands, Hudson Strait	6 50		
Byron Bay, Australia, East coast	9 45	6	
Cabita Bay, New Granada	3 40	12	
Cacheo River, Africa, West coast	7 45	8	
Cachipour, Cape, Brazil	5 52	7–10	
Cadiz, Spain	1 23	12¾	8¼
Caen, France	10 57		
Caermarthen, (Bar)	5 44	26	19½
Caernarvon, Wales	9 33	13¾	10½
Cagayan Sulu	6 10	6	
Calmites, St. Domingo	8 0?	1?	
Cairnlough, Ireland	10 51	5½	5
Cajeli Bay, Bouro	1 0	6	
Calais, France	11 49	19½	15½
Calandorang, Balabac Island	11 0	6	
Calbuco, Patagonia, West coast	1 22	15–20	
Calcutta, Bengal	2 30	12–15	
Caldy Road, Bristol Channel	5 40	24?	16?
Calabar River, Africa, West coast	4 5	6	5
Calabar River, Old, Africa, West coast	5 0	6½	5
Caledonia Harbor, New Granada	11 40	1½	1
Calf Sound, Isle of Man	11 17	16½	13
Calicut Roads, Hindoostan, West coast	12 15	4	3½
Callao Bay, Peru	5 47	4	
Calshot, (Castle Point,) England	11 30	13	9½
Calstock, River Tamar, England	6 6	12½	8½
Camaguin, Babuyan Islands	6 0	6	
Camariñas, Port, Spain	3 0	15	
Cambay, (town,) Hindoostan, West coast	5 20	day 23 night 30	
Cambing, Banda Sea	Noon	6	
Camden Harbor, Australia, Northwest coast	11 30	30	
Cameleon Harbor, Nodales Channel, British Columbia.	3 0	16	11½
Cameroon River, Africa, West coast	5 15	7	5
Campbell, Cape, New Zealand	6 0	8	6
Campbell Island, South Pacific	Noon	3½	
Campbell Town, Gulf of St. Lawrence	4 0	10	7
Campbellton, Scotland	11 45	8½	6
Campeche, Yucatan	1 45	2½	2
Campobello, (Welchpool,) Bay of Fundy	11 21	23½	20
Cancale, France	6 20	37	27
Canna Island, Scotland, West coast	6 19	14	9½
Canso Gut, (North entrance) Nova Scotia	9 15	4	2
Canso Gut, (Plaister Cove,) Nova Scotia.	9 10	4½	3
Canso Harbor, Cape Breton Island	7 48	6½	4½
Cantin, Cape, Africa	10 0	10	
Canton River, (entrance,) China	10 0	8	
Canton River, Kuper Island, in March	2 40	5½	
Canton River, Kuper Island, in May and June	1 40	5½	
Cape Coast Castle, Africa, West coast	4 30	6	
Car Nicobar, Nicobar Island	10 0	5	
Caracas River, Ecuador	3 30	10	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise.	
			Springs.	Neaps.
	h.	m.	Feet.	Feet.
Caraquette Harbor, Gulf of St. Lawrence . .	2	40	6	3
Carbonear, Newfoundland	7	20	4½	3
Cardiff, (Penarth,) Wales	6	56	37½	29
Cardigan, Wales	7	1	12	9
Cardigan Bay, Prince Edward Island . . .	8	40	5	3½
Careening Bay, Australia, Northwest coast . .	11	45	30	
Carelmapu, Patagonia, West coast	0	50	10	
Cargados, Carajos Shoals, Indian Ocean . .	2	0	4	
Cargreen, River Tamar, England	5	47	14½	10¾
Caribou Harbor, Nova Scotia	10	0	6	4
Carlandagan Islands, Bird Island, Palawan, East coast.	9	30	6	
Carleton Point, Gulf of St. Lawrence . . .	3	0	6	4
Carlingford Bar, or Cranfield Point, Ireland .	11	0	14	11
Carlisle Port, England	0	10	20	14
Carlos, San, Port, Patagonia, West coast . .	11	15	6	
Carlos, San, Arenas Point, Patagonia, West coast	0	14	6	
Carlos, San, English Bank, Patagonia, West coast	0	4		
Carlos, San, Port, Falkland Islands	7	0	8	
Carenage, Trinidad, Caribbee Islands . . .	4	20	4	2½
Carnot Bay, Australia, West coast	0	30	13–14	
Carouge River, River St. Lawrence	7	15	16	11
Carrigaholt, Ireland	4	44	14	10½
Carsaig, Scotland	5	28	10	7½
Cartagena, New Granada	11	0	1½	1
Carteret, France	6	25	31	22½
Carteret, Port, New Ireland	.	.	6	
Carwar, or Sedashigar Bay, Hindoostan, West coast.	10	0	6½	5
Cascumpeque Harbor, Prince Edward Island .	5	40	3	2
Cashla Bay, Ireland	4	33	16	12
Casquets, English Channel	6	45	15½	
Castillos, Cape, Rio de la Plata	8	30	2	
Castlereagh, Cape, Tierra del Fuego	2	50	4	
Castletown, Bearhaven, Ireland	4	14	9¾	7½
Castletown, Isle of Man	11	10	20	16
Castletownsend, Ireland	4	21	10¾	8
Castors Harbor, Newfoundland	10	50	5?	
Castri Bay, Gulf of Tartary	10	30	5½–6½	
Castro, Patagonia, West coast	9	11	18	
Casuarina Point, China Sea, East coast . . .	9	30	6¾	
Catalina Harbor, Newfoundland	7	0	6	4
Catharina, Santa, Island, Brazil	2	45	6	4½
Catharine, St., Point, Magellan Strait	8	5	30	
Catlin River, New Zealand	2	30	8	6
Cato Bank, Australia, East coast	8	0	6	
Catoche, Cape, Yucatan	9	30	1½	
Cattawade Bridge, Stour River, England. . .	1	8	4½	
Cavalli Islands, New Zealand	8	0	7	
Cavern Island, China Sea, East coast	9	30	5½	
Cawee Islands, Gulf of St. Lawrence	1	50	9	5
Cayenne, Guayana	4	51	7	
Cayeux, France	11	5	27½	21
Ceara, Brazil	5	35	8½	
Cedeira, Spain, North coast.	3	0	15	
Centre Island, Foveaux Strait, New Zealand .	0	15	8	6
Ceram, Wahaay Harbor, Moluccas	6	0	3	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise.	
			Springs.	Neaps.
	h.	m.	Feet.	Feet.
Cerros Island, California	9	10	7–9	
Ceuta, Africa, North coast	2	6	3¾	½
Chacao Bay, Patagonia, West coast	0	40	14	
Chacao Narrows, Patagonia, West coast	0	50	16	
Chalky Inlet, New Zealand	11	5	8	4
Chalmers, Port, America, Northwest coast	1	0	13¾	
Chamé Bay, New Granada	4	0	16	
Chamisso Island, America, Northwest coast	4	42		
Champion Bay, Australia, West coast	9	10	1	
Champlain, River St. Lawrence	9	45	3	2
Changchi Island, China, East coast	9	30	17	
Change Island, Newfoundland	7	20	4½	3
Changues Islands, Patagonia, West coast	0	35		
Chapu Road, Hang-chu Bay, China, East coast	Noon		25	
Charles Island, Galapagos Islands	2	10	6	
Charles Island, Labrador	7	30	6–7	
Charlowka River, Lapland	8	8	12	
Chateau Bay, Labrador	7	35	3½	1
Chatham, England	1	11	18	14½
Chatham Island, Galapagos Islands	2	23	6½	
Chatham Island, Port Hutt, South Pacific	6	50	6	
Chatham, Port, America, Northwest coast	1	0	12	
Chauan Bay, China, East coast	11	0	6½	
Chausèe de Sein, France	3	21	17½	12
Chausey, Isles de, France	6	9	35	26
Cheduba, Bay of Bengal	11	30	8	
Chee-fow Harbor, Yellow Sea. (See Chifu.)				
Chentabun River, China Sea, West coast	10	0	5½	
Chepo River, New Granada	3	40	16	
Chepstow, England	7	30	38	28½
Cherbaniani Reef, Laccadives, Indian Ocean	10	0	7	4
Cherbourg, France	7	49	17	12¾
Chesilton, England	6	13	10½	7
Chester, (Crane Wharf,) England	0	16	10	
Chesterfield Islet, Australia, East coast	8	30	5	
Chetican, Cape Breton Island	8	15	3½	
Chichester, England	11	30	14	11
Chifu, Yellow Sea	10	34	8	6½
Chimmo Bay, China, East coast	10	20	16	
Chimney Island, Rees Pass, China, East coast	11	30	12	
Chinchu Harbor, China, East coast	0	25	17*	
Chin-hae, Yung River, China, East coast	11	20	12½	
Ching-tau Bay, Yellow Sea	6	0	12	9
Chino Bay, China Sea	7	0	6–7	
Chittagong, (Bar,) Bay of Bengal, East coast	0	45	15	10
Chodo Island, Korea, West coast	6	20	12	
Choiseul, Port, Madagascar, East coast	4	0	5	
Chosan Harbor, or Tsau-liang-hai, Japan Sea	7	45	7	5
Christchurch, England	9 11	0 30	5	
Christianstæd, Santa Cruz	7	30	¾	
Christmas Island, Indian Ocean	10	0		
Christmas Harbor, Kerguelen Island	2	0	2	
Chuen-pee Point, Canton River	2	0	7¾	
Churruca, Port, Strait of Magellan	1	0	6	
Chusan Archipelago, (Vernon Channel,) China, East coast.	9	40	14	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise. Springs.	Rise. Neaps.
	h.	m.	Feet.	Feet.
Chusan Tinghæ, China, East coast	11	0	12	9
Circular Head, Tasmania	11	40	9	
Clam Point, Bay of Fundy	8	27	8¼	6¼
Clara, Santa, Island, Ecuador	4	0	11	
Clare Island, Ireland	4	38	12½	9¼
Clarence, Port, America, Northwest coast	4	25		
Clarence Harbor, Long Island, Bahamas	8	30	4	3½
Clarence River, South Head, Australia, East c'st	8	30	4	
Clarke Harbor, Bay of Fundy	8	40	9¼	7
Clayoquot Sound, Vancouver Island	Noon		12	
Clear, Cape, Ireland	4	0	9	6¼
Clearwater Point, Gulf of St. Lawrence	11	30	5	3
Cleveland Bay, Australia, East coast	7	30	10–12	
Cley, England, Northeast coast	.	.	5¼	
Clifden Bay, Ireland, West coast	4	30	13½	10
Clonakilty Bay, Ireland	10	30	11	8¼
Coacoacho Bay, Gulf of St. Lawrence	4	30	5	3
Cobija Bay, Bolivia	9	54	4	
Cocagne River, Gulf of St. Lawrence	7	30?	4?	2?
Cochin Harbor and Road, Hindoostan, West coast.	1	30	2½	2
Cockburn Island, Antarctic Ocean	7	50	6	
Cockburn, Port, Africa, East coast	4	15	12	
Cockburn, Australia, North coast	5	45	24	
Cockburn Sound, Australia, West coast	9	0	1–1½	
Cockenzie, Firth of Forth, Scotland	2	16	15¾	13
Codroy Island, Newfoundland	9	15	6	4
Coghlan Anchorage, America, Northwest coast	0	30	18	14
Colarado, River La Plata	4	0	9	7½
Colarados, River La Plata	3	40	11	
Coleraine, Ireland	6	24	6½	4
Collier Bay, Australia, Northwest coast	11	45	36	
Colne Point, Colne River, England	Noon		14	10
Colombilla Cay, Pearl Cays, Caribbean Sea	2	0	2	
Colombo, Ceylon	1	0	2	
Colonsay, (Schallasaig,) Scotland, West coast	5	18	11	7½
Comau Inlet, Patagonia, West coast	1	10	17	15¾
Comboyuro Point, Australia, East coast	9	30	4–7	
Componee River, Africa, West coast	10	0	15	11½
Conani River, Brazil	6	38	19	
Concarneau, France	3	12	13	9½
Condore, Cochin China	3	0	4	
Congo River, Africa, West coast	4	30	6	
Congoon Bay, Persian Gulf	7	45	9½	
Conil, Spain	1	18	12	7½
Conquet Road, France	3	46	21	15
Constitucion Cove, Bolivia	10	0	4	
Conway, Cape, Australia, East coast	11	0	18	
Cook Harbor, Newfoundland	7	25		
Coondee. (See Kúdi.)				
Cooper, Port, New Zealand	3	50	7½	5½
Copiapo, Chile	8	30	5	
Coquet Road, England, East coast	3	0	14½	11
Coquimbo Bay, Chile	9	8	5	
Cordouan Light-house, France	3	37	13¾	10½
Corentyn River, Guayana	5	10	8¼	6
Coringa, or Cocanada Bay, Bay of Bengal, West coast.	9	10	4–5	3

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Coringa River, (Bar,) Bay of Bengal, West coast	9 0	5	
Corisco Bay, (Elobey Isles,) Africa, West coast .	5 0	7	
Cork, (Penrose Quay,) Ireland	4 58	12¾	10
Corn Islands, Bay of Honduras	1 45	2	
Corner Inlet, South Australia	0 14	8	
Cornwall, Cape, England	4 35	18?	13?
Corny Point, Australia, South coast	2 45	4	
Corpach, (Loch Aber,) Scotland	5 59	11½	
Corran, (Loch Linnhe,) Scotland	5 43	12	8½
Corunna, Spain	3 0	15	
Coudres Island, (Prairie Bay,) River St. Lawrence	4 25	17	10
Courseulles, France.	9 7	20	15½
Courtmacsherry, Ireland	4 36	10¾	8¼
Coverack, England	4 35	14½	11½
Cow Head Harbor, Newfoundland	10 41	8½	6½
Cowes, (West,) England.	{ 10 45 / 11 45 }	12½	9½
Coy Inlet, Patagonia, East coast	9 30	40	
Coyhuin River, Chile	0 52	21	
Cozumel, Bay of Honduras	8 30	1½	
Crane Island, River St. Lawrence.	5 24	17	13
Cranford Bay, Mulroy Bay, Ireland	8 3	4	
Crapaud, Prince Edward Island	10 0	8	6
Crémaillére Harbor, Newfoundland	7 13	4½	2¾
Crichton Harbor, Korea, South coast . . .	9 50	11½	8½
Crimon Islands, Java Sea	8 0	6	5
Crinan, Scotland	4 49	6½	5
Croc Harbor, Newfoundland	6 30	4½	
Croisilles Harbor, New Zealand	9 0	12	8
Cromarty, Scotland	11 56	14	11
Cromer, England	7 0	14¾	11
Crow Harbor, Nova Scotia	8 0	6½	4½
Crowdy Head, Australia, East coast	9 15	5	3
Crooked Island, Bahamas	7 0	2½	
Crookhaven, Ireland	4 9	9¾	8
Cucao Bay, Patagonia, West coast	Noon	6	
Cuckolds Point, River Thames, England . .	1 45	19?	15?
Culdaff Bay, Ireland, West coast	5 53	8¾	6
Culebra, or Passage Island, Caribbean Sea . .	9 0	1	
Culiacan River, Mexico, West coast	11 30	6?	
Cullen Harbor, Fife Sound, British Columbia .	12 0	16	11½
Cumberland Basin, (Sackville,) Bay of Fundy .	11 55	45½	38
Cumsingmun Harbor, Canton River, China .	0 6	6½	
Cupchi Point, China, East coast	8 0		
Cupica Bay, New Granada	3 30	13	
Curieuse, Seychelles, Indian Ocean	5 10	7	
Curtis, Port, Australia, East coast	9 40	10–12	
Cutwell Harbor, Newfoundland	7 0?	2–4?	
Cuxhaven, Germany	1 8	10	
Cypress Harbor, Sharp Passage, British Columbia	Noon	16	11½
Daggs Sound, New Zealand	11 30	8	6
Dahouet, France	6 5	32	23½
Dalawan Bay, China Sea, East coast	11 0	5	
Dalcahue, Patagonia, West coast	0 26		
Dalhousie Harbor, Gulf of St. Lawrence . .	3 10	9	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise.	
			Springs.	Neaps.
	h.	m.	Feet.	Feet.
Dalkey Island, Ireland	10	45	13	11
Dalrymple Bay, Madagascar, West coast	5	0	15	
Dalrymple, Port, Tasmania	0	5	10	7½
Dampier Strait, Moluccas	.	.	11	
Danes Island, Spitzbergen	0	24	5½	
Danger Point, Australia, East coast	9	30	6	4½
Darnley Island, Torres Strait	9	30	12	
Darra Salaam, Africa, South coast	4	0	12	
Dartmouth, England	6	16	14½	10½
Darwin Harbor, Choiseul Sound, Falkland Islands.	6	30	5½	
Darwin, Port, Australia, North coast	5	25	16–24	2–12 Irreg.
Dauphin, Fort, Madagascar	4	30	7	
Davy Point, Bay of Bengal	8	15	6	
De Roompot, Onrust, North Sea	1	0	15	11
Deal, England	11	15	16	12½
Dealy Island, Melville Island	1	48	4	
Deep Harbor, Fife Sound, British Columbia	Noon		16	11½
Deep Point, Durian Strait	5	0	10	
Deer Harbor, Newfoundland	7	49	3½	2
Deer Sound, Orkneys	10	30	10	7½
Delagoa Bay, (Port Melville,) Africa, South coast	4	30	15	
Delagoa Bay, (Portuguese Factory,) Africa, South coast.	5	20	12	
Delagoa Bay, Shefeen Island, Africa, South coast	4	40	12	
Delfzijl, Germany	11	30	8½	
Delgado, Cape, Africa, East coast	4	0	16	11½
Demerara River, Guayana	4	20	9	4
Denham Sound, Shark Bay, Australia, Northwest coast.	0	5	5	
Denial Bay, Australia, South coast	0	15	6	
Denison, Port, Australia, East coast	9	30	6	
Deoghur Harbor, (entrance,) Hindoostan, West coast.	11	0	9	7
Depuch Isle, Australia, West coast	10	40	14	10
Desire, Port, Patagonia, East coast	0	10	18½	
Devarenne Strait, New Caledonia	.	.	3½	
Devonport Dockyard, England	5	43	15½	11½
Dhardur River, (entrance,) Hindoostan, West coast.	4	30	27	20–22
Dheli River, Sumatra	3	0	8	
Diamond Island, Bay of Bengal	10	30	8	
Diamond Point, Malacca Strait	Noon		9½	
Diego, San, Cape, Tierra del Fuego	4	30	10	
Diego Garcia Island, Indian Ocean	1	30	6	
Diego Ramirez Islands, Tierra del Fuego	4	0	6	
Dielette, France	6	40	27	20½
Dieppe, France	11	6	27	20½
Digby Gut, Bay of Fundy	11	0	27½	23
Dilhi, or Dielli, Timor	1	0	6	
Dillon Bay, Erromango Island, New Hebrides	5	30	4	
Dingle, Ireland	3	51	10½	7½
Direction Hill, Magellan Strait	8	53	38	23
Discovery, Port, America, Northwest coast	2	30	7	
Dislocation Harbor, Tierra del Fuego	1	40	4	
Diu Harbor, Hindoostan, West coast	11	0	6	4½

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise.	
			Springs.	Neaps.
	h.	m.	Feet.	Feet.
Dives, France	9	39	21	16
Divy Point, Bay of Bengal	.	.	5	
Dodandowe Bay, Ceylon	1	50	1½	
Dodo River, Bight of Benin	4	17	5	
Domingo, San, Port, Patagonia, West coast	Noon		7	
Domino Run, Labrador	6	40	7	4
Donaghadee, Ireland	11	13	11½	9
Donegal Harbor, Ireland	5	18	11½	8½
Doris Cove, Tierra del Fuego	3	0	4	
Dornock Road, Scotland	11	47	11	
Douany, Comoro Islands	4	0	11–12	
Douglas, Isle of Man	11	12	20¾	16
Douglas Road, Bahamas	8	30	4	2½
Dover, England	11	12	18¾	15
Downham Reach, Orwell, England	0	27	12	
Drayton Harbor, St. Juan de Fuca Strait	2	0	12	
Drogheda, (Bar,) Ireland	11	0	14	11
Duart, Isle of Mull	5	0	12	10
Dubba River, Hindoostan, West coast	10	10	8	
Dublin, (Bar,) Ireland	11	12	12–14	9–11
Duck Cove, New Zealand	10	50		
Dumbarton, Scotland	0	20	9	
Dumrah River, (Bay of Bengal)	8	45	10	
Dunbar, Scotland	2	8	14½	11
Dunbeacon, Ireland	3	51	10½	7½
Duncansby Ness, Scotland	10	14	8½	6
Dundalk, Ireland	10	56	13½	11½
Dundee, Scotland	2	32	14½	11½
Dungeness, England	10	45	21¾	19
Dungeness, Magellan Strait	8	30	36	
Dunk Island, Australia, East coast	9	28	6–10	
Dunkerque, France	11	55	16¾	13½
Dunkerron, Kenmare River, Ireland	3	45	10½	8
Dunmanus Harbor, Ireland	3	57	9½	7½
Dunmore, Ireland	5	27	12½	9¾
Durnford, Port, Africa, East coast	4	45	12	
Dusky Bay, New Zealand	11	15	10	6
Dvina, (Bar,) White Sea	.	.	3½	
Dyer Island, Africa, South coast	2	50	5	
Easdale Sound, Scotland	5	10	10–12	
Easter Island, South Pacific	0	39		
East Cape, New Zealand	8	55	7	
East Point, Prince Edward Island	8	30	3½	2
East Alligator River, Australia, North coast	8	15	15	
East London, Africa, South coast	3	45	4½	
Eclipse Harbor, Labrador	.	.	5	
Ecrehos, France	6	32	31	22½
Eddystone Point, Australia, East coast	9	39	7	
Eden Harbor, Patagonia, West coast	0	15	6	
Edgar, Port, Falkland Islands	7	15	6	
Edge Passage, America, Northwest coast	1	30	17–22	14–17
Edina, Africa, West coast	5	50	4	
Edmonstone Island, Sherbro River, Africa	.	.	.	8
Egg Island, Gulf of St. Lawrence	2	0	11	6
Egmont Bay, Prince Edward Island	3	0	4	2
Egmont, Port, Falkland Islands	7	30	11	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Eider River, (entrance,) North Sea	Noon	10	
Eider River, Tönning	1 55	11½	
Eides Fiord, Færoe Islands	11 0	9½	7½
Eigg Island, Scotland	6 15	14	10
Elbe, (entrance,) Germany	Noon	11	
Elbe, Outer light-vessel, No. 1	0 15	9½	
Elena, Santa, Port, Patagonia, East coast	4 0	17	
Elena Bay, Ecuador	1 18	8	
Elizabeth Bay, Africa, Southwest coast	. .	5–6	
Ellen, Port, Islay	5 0	5	4
Ellenwoods Anchorage, Bay of Fundy	9 54	13	10½
Elliot, Port, Australia, South coast	. .	5–6	
Emden, Germany	0 34	9	
Ems River, (outer buoy,) Germany	10 0	8–10	
Encounter Rock, Yellow Sea	10 44	11	8
Endeavor River, Australia, North coast	8 0	5–10	
Endeavor Strait, Australia, North coast	1 0	9½	
Endermo Harbor, Japan	4 35	5	
English Bank, San Carlos, Patagonia, West coast	0 4		
English Harbor, Antigua	. .	2	
English River, Delagoa Bay, Africa, South coast	7 30	5	
Enora Bay, Japan	. .	4	
Eran Bay, (Palawan,) China Sea, East coast	10 10	6½	
Erebus Bay, Barrow Strait	0 6	8	
Erme River, Bigbury Bay, England	5 40	16½	11½
Erqui, France	5 59	33½	24½
Erronan, or Futuna, New Hebrides	7 24	4	
Escumenac Point, Gulf of St. Lawrence	4 10	4	2½
Esperanza Inlet, Vancouver Island	Noon	12	
Espirito Bay, Brazil	3 0	4	
Espiritu, Santo, Cape, Magellan Strait	8 30	36–42	
Esquimalt, St. Juan de Fuca Strait	Irregular	7–10	5–8
Essington, Port, Australia, North coast	3 24	13	
Estevan, San, Port, Patagonia, West coast	0 15	5	
Etches, Port, America, Northwest coast	1 15	9½	
Evangelists, Patagonia, West coast	1 0	5	
Exmouth, England	6 21	12½	8½
Expedition Bay, Korea	2 30	2½	
Exuma, Bahamas	7 20	2½	
Eyemouth, Scotland	2 15	15?	11?
Eyre, Port, Australia, South coast	10 30	6	
Fair Isle, Shetlands	11 0	5	3
Fairy, Port, Australia, South coast	0 31	3	
Falkland Sound, (North entrance,) Falkland Islands.	6 45		
Falkland Sound, (South entrance,) Falkland Islands.	7 0		
Fall Harbor, Labrador	6 40	3½	
Falmouth, England	4 57	16	12
False Point, Bay of Bengal, West coast	8 15	8	
Famine, Port, Magellan Strait	Noon	6	
Fanning's Island, South Pacific	. .	4	
Fanny Hole, Mulroy Bay, Ireland	6 17	9½	8
Fansiak Channel, Canton River, China, East coast.	1 0	7½	5
Fareham, (close to the Upper Quay,) England	11 48	11½	8½

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise.	
			Springs.	Neaps.
	h.	m.	Feet.	Feet.
Fareham Bridge, England	11	51	7½	4½
Farewell, Cape, New Zealand	9	20	14	10
Fatsizio, Japan	6	0	5	
Fayal, Azores, Atlantic Ocean	11	45	4	
Fécamp, France	10	44	23½	18
Fénérine, Madagascar	.	.	3½	
Fenit, Tralee Bay, Ireland	4	3	12½	9½
Feolin Ferry, Jura	4	41	6½	4½
Fernando, Noronha Island, South Atlantic	4	0	6?	
Fernando Po, Bight of Biafra	4	0	7	
Ferolle Cove, New, Newfoundland	10	50	5?	
Ferolle Harbor, Old, Newfoundland	9	28	4½–6½	
Ferribly Sluice, River Humber	6	41	20½	
Ferro, Canary Islands	0	30?	9?	
Ferrol, Spain	3	0	15	
Ferry Side, South Wales	5	49	23	16½
Filey Bay, England	4	20	16	12½
Finisterre, Cape, Spain	3	0		
Fish Head, Gulf of Manan, Bay of Fundy	11	16	22½	18½
Fishguard, Wales	6	56	11½	8½
Fitz-Roy Island, Australia, East coast	9	15	7–12	
Fitzroy Port, Falkland Islands	4	45	6	
Flamand Bay, St. Domingo	Irregular		2–3?	
Flamborough Head, England	4	30	16	12
Flamenco, Port, Chile	9	10	5	
Flatholm Islands, Bristol Channel	6	54	37?	28?
Fleetwood, Port, England	11	12	26½	19½
Fleetwood, Wyre Light	11	11	27½	20½
Flesh Bay, or Bay St. Bras, Africa, South coast	3	30?	6?	
Fleur de Lis Harbor, Newfoundland	7	15	2–4	
Flinders Group, Australia, East coast	9	15	8–12	
Flushing, Belgium	0	54	15	11
Fog Islands, Hang-chu Bay, China, East coast	11	45	17	
Fogo Island, Newfoundland	7	20	4	
Folkestone, England	11	7	20	16½
Folly Point, Petitcoudiac River, Bay of Fundy	11	49	45	38
Fongwhang Group, (Bullock Harbor,) China, West coast.	8	30	17	
Forçados River, Bight of Benin	4	22	5	
Fore Carreah River, Africa, West coast	7	40	11	
Formby Point, England	10	35	28	
Formoza, Mt., Malacca Strait	8	0	11	8½
Fort Dauphin, St. Domingo	7	0	5½	3½
Fortune Bay, Patagonia, West coast	0	50	7	
Forward Harbor, British Columbia	3	0	16	11½
Foulness, Crouch River, England	0	5	14½	10½
Fowey, England	5	14	15	11½
Fowler's Bay, Australia, South coast	10	30	6	
Fox Bay, Falkland Islands	7	0	6	
Foyle Lough, (Warrenpoint,) Ireland	6	20	6½	5
Foynes Island, Ireland	5	35	15½	12
France, Port de, or Noumea Bay, N. Caledonia	8	25	4	
Francis, St., Bay, Tierra del Fuego	4	0		
Francis, St., Cape, Africa, South coast	3	34	5	
Fraser River, (entrance,) British Columbia	6	30	7–10	
Fraserburg, Scotland	0	40	11	8½
Frechette Island, River St. Lawrence	8	0	14	9

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise. Springs.	Rise. Neaps.
	h.	m.	Feet.	Feet.
Frederick Reef, Australia, East coast	8	0	6	
Frederickshaab, Greenland	6	3	12½	9½
Fredriken Siel, Germany	11	15	4	
Freycinet Estuary	4	15	3½	
Freycinet Reach, Shark Bay, Australia, Northwest coast.	3	0	5	
Frio, Porto, Brazil	2	40	4½	
Fugloe Fiord, Färoe Islands	11	15	6½	4½
Funchal Bay, Madeira	0	48	7	
Funk Island, Newfoundland	7	0?	2–3?	
Fury Cove, Patagonia, West coast	1	15		
Fury Harbor, Tierra del Fuego	2	30	4	
Fury Island, Tierra del Fuego	2	30	4	
Fury and Hecla Strait, Arctic Regions	7	0	8	
Gaalong Bay, Hainan Island, China Sea	.	.	4–5	
Gabo Island, Australia, South coast	8	50	6	
Gaboon River, Africa, West coast	5	30	7	5
Gallant, Port, Magellan Strait	0	34	8	
Galle, Pointe de, Ceylon, South coast	2	0	2	
Gallegos, Port, Patagonia, East coast	8	50	46	
Gallinas River, Africa, West coast	6	45	4	
Galloway, Mull of	11	15	15?	12?
Galway, Ireland	4	35	14½	11
Gambia River, Africa, West coast	8	10	6–9	
Gambier Islands, Australia, South coast	2	0	5	
Gambier Islands, South Pacific	1	50		
Garliestown, Scotland, West coast	.	.	17	12
Garroch Head	1	49	10	
Gaspé Basin, Gulf of St. Lawrence	2	40	5	3
Geby, Fohou Island, Gilolo Passage, Moluccas	.	.	5	
Geelong Harbor, Australia, South coast	2	30	3½	2½
George, Cape, Nova Scotia	9	15	4	2
George d'Elmina, St., Africa, West coast	4	30	6	
George, Port, Bay of Fundy	11	17	32	28
George, St., Basin, Australia, Northwest coast	0	20	24–37	
George, St., Harbor, Newfoundland	10	3	6½	4½
George's Bay, Tasmania	9	42	3	2
George's, St., Sound, Gulf of Mexico, middle entrance.	1	31	1½	1½
George's, St., Sound, Gulf of Mexico, west entrance.	Irregular		2½–4	
Geriah, or Viziadroog, Hindoostan, West coast	11	0	9	7
Germain, St., France	6	20	34	25
Ghubbet, Ghazirah	9	30	10	
Ghubbet, Ne, Sokotra. Indian Ocean	7	0 (irr.)	7	
Ghubbet, Gollonsir, Sokotra, Indian Ocean	7	20	8	
Ghubbet, Hashísh, Arabia, Southeast coast	10	0	10	
Gibraltar, (new Mole,) Spain	1	47	4	2½
Gigha Sound, Scotland	2	22	4	2½
Gijon Bay, Spain, North coast	3	0	14	11
Gilmorris Island, Africa, West coast	6	0	11	
Gipp's Land Lakes, (entrance to,) Australia, South coast.	8	30	3	
Gizri River, Hindoostan, West coast	9	45	10	
Glasgow, Scotland	1	25	9	7½
Glasgow, Port, Scotland	0	18	9	

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Glenan Iles, France	3 12	13	10
Glennie Isles, Australia, South coast	11 44	9	
Gloucester, England	9 45?	4–7	
Gloucester, Cape, Tierra del Fuego	1 30	5	
Gluckstadt, Germany	3 9	11½	
Goa Bay, Hindoostan, West coast	10 30	7	5½
Goapnáth Point, Hindoostan, West coast	2 25	18	13½
Goeree Gat, North Sea	2 0	7½	
Gogah, Hindoostan, West coast	3 50	27–30	21
Gold Stream Harbor, America, Northwest coast	1 0	15	12
Golovnin Bay, America, Northwest coast	6 23	3¾	
Gomera, Canary Islands	0 45?	9?	
Gometra, Loch Tuadh, Isle of Mull	5 29	11¾	8
Gonaives Bay, St. Domingo	8 0	1	
Good Bay, Newfoundland	10 40	7½	5½
Goods Bay, Patagonia, West coast	0 30	7	
Good News, British America, Northwest coast	6 15	13½	
Good Success Bay, Tierra del Fuego	4 3	6–8	
Goodbout River, Gulf of St. Lawrence	1 52	11	6
Goold Island, Australia, East coast	6 45	6	
Goole, River Humber, England	7 26	13	
Gooria Creek, (entrance,) Hindoostan, West c'st	11 0	8½	
Goose Cove, Newfoundland	7 0?	2–3?	
Gorda Sound, Virgin Islands	8 30	1½	
Gore, Port, New Zealand	9 0	8	6
Gorée, Africa, West coast	7 45	2½	
Goree Road, Tierra del Fuego	4 0	8	
Goulburn Islands, Australia, North coast	6 0		
Goury, France	7 6	22	7½
Gowlland Harbor, Discovery Passage, Vancouver Island.	5 30	11	
Gracia Point, Strait of Magellan	10 17	8	
Gracias, Cape, Harbor, Bay of Honduras	10 30	2	
Grand Cestos, Africa, West coast	5 20	4	
Grand Harbor, Grand Manan, Bay of Fundy	11 7	21	17½
Grand Lahou, Africa, West coast	4 20	4	
Grand Passage, Bay of Fundy	10 43	20¾	17
Grand, Port, Mauritius	1 0	1½	
Grand Rustico, Prince Edward Island	6 40	4	2
Grande-digue, Madame I., Cape Breton Island	7 55	6½	4½
Grande Point, Chile	9 45	5	
Granton Pier, Scotland	2 20	16	12½
Granville, France	6 13	37	27½
Gravelines, France	Noon	19	15
Graves, Port, Howe Sound, Gulf of Georgia, British Columbia.	Noon	12	
Gravesend, England	1 10	17½	14
Great Barrier Island, (Nagle Cove,) New Zealand.	6 25	10	7
Great Barrier Reef, Australia, East coast	8 48	7	
Great Fish Bay, Africa, West coast	2 30	5–6?	
Great St. Lawrence Harbor, Newfoundland	8 30	7	4
Great Sandy Strait, Inskip Point, Australia, East coast.	8 30	6	
Greatman Bay, Ireland	4 39	15½	11½
Green Island, River St. Lawrence	2 45	16	9½
Greencastle Point, Ireland	11 2	14	11½

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Greenock, Scotland	0 8	9¾	8¼
Greenwich, England	1 43	19	15
Green's Harbor, Newfoundland	6 44	3½	
Gregory Bay, Magellan Strait	9 30	21	12
Gregory, Port, Australia, West coast	11 30	3	
Grenada, (St. George Harbor,) Caribbee Islands	2 40	1½	¾
Grenadines, Caribbee Islands	3 0	1½	1
Grey, Port, Swan River, Australia, West coast	9 0	1–1½	
Grey River, New Zealand	10 15		
Greytown, Mosquito Coast	9 0	1½	
Gribanika Pt., White Sea	4 50	3	
Griffin Bay, Haro Archipelago	Irregular	12	
Griffith Island, Barrow Strait	0 15	3¾	2¾
Griguet Bays, Newfoundland	7 0?	2–3?	
Grimsby, England	5 36	19¾	15
Grindstone Island, Bay of Fundy	11 47	41	34½
Grisnez, Cape, France	11 27	21½	16¾
Grondine, River St. Lawrence	9 0	9	6
Gruinard Island, Scotland, West coast	6 37	14½	
Guadaloupe, (Point á Pitre)	10 0	1½	
Guayaguayare Bay, Trinidad	4 25	7	4
Guambacho Bay, Peru	6 0	2	
Guardafui, Cape, Africa, East coast	6 15	6	
Guarmey Bay, Peru	6 0	2	
Guatulco, Mexico, West coast	1 30	5	
Guayaquil, Ecuador	7 0	11	
Guaymas, Mexico, West coast	8 0	4	
Guernsey, (St. Peter Port,) English Channel	6 37	26	18¾
Guia Narrows, Patagonia, West coast	2 10	8	
Guinchos Kay, Bahamas	7 40	3	
Guichen Bay, Australia, South coast	0 37	4	
Gun Cay, Bahamas	8 30	3	
Gundavi River, (entrance,) Hindoostan, West coast.	2 0	19	15½
Gunfleet Sand, England	11 40	12	8
Gutzlaff Island, China, East coast	11 30	15	
Guysborough, Nova Scotia	8 20	6½	4½
Gweedore, (Bunbeg,) Ireland	5 32	11	8
Haarlem, Netherlands	9 0		
Habitable Island, Lapland	7 9	9	
Habitants Harbor, Cape Breton Island	8 20	6½	4¾
Hachken River, Japan	6 4	6½	
Haimun Bay, China Sea	9 0	6–7	
Haïti, Cape, St. Domingo	6 0	3	
Haiyun-tau, (Thornton Haven,) Yellow Sea	9 30	12	8
Hajamri River, Hindoostan, West coast	9 40	8	
Hakluyt Head, Nova Zembla	1 30	4	
Hakodadi Harbor, Yezo Island, Japan	5 0	4	
Halifax, Nova Scotia	7 49	6	5
Halt Bay and Gray Harbor, Patagonia, West c'st	0 15	6	
Hamburg, Germany	5 29	7½	
Hamilton, Port, (Korea,) Yellow Sea	8 30	11	
Hammelin Pool, Shark Bay, Australia, North-west coast.	5 0	3½	
Hammerfest, Norway	1 10	9	
Hammond Knoll, England, East coast	7 40		

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Han-kau, China, West coast	. .	33–38	
Hangata, Japan	10 36	11½	5
Hang-chu Bay, (Seshan Islands,) China, East c'st	11 45	14	
Hang-chu Bay, (Fog Islands,) China, East coast	11 45	17	
Hang-chu Bay, (Chapoo Road,) China, East coast	Noon	25	
Hang-chu Bay, (off Can-pu,) China, East coast	. .	32	
Hanover Bay, Australia, Northwest coast	11 30	24–38	
Hanover Sound, Bahamas	8 15	4	3
Hanstul, (mouth,) Gulf of Kutch, Hindoostan	2 0		
Hants Harbor, Newfoundland	7 13	4	3
Harbor of Mercy, Magellan Strait	1 22	4	
Harbor, Grace, Newfoundland	7 25	4½	3
Harbor Island, Nova Scotia	7 40	6½	4½
Hardy, Port, New Zealand	9 55	8	6
Haro Strait, (Channels leading to, from St. Juan de Fuca Strait.)	Irregular	10–12	
Harrington, Port, England	11 15	23	18
Hartlepool, England	3 28	15	11½
Harvey, Port, (Call Creek,) Vancouver Island	0 30	10	
Harwich, England	0 6	11½	9½
Hastings, England	10 53	24	17½
Hastings Harbor, Bay of Bengal, East coast	10 40	13½	
Hatiling Bay, Moluccas	6 0	3–4	
Haute Isle, Bay of Fundy	11 21	33	28½
Havana, Cuba	8 14	3	
Havannah Harbor, Sandwich Islands, New Hebrides.	7 15	4	
Haverfordwest, Wales	6 42	7½	2½
Havre, France	9 51	22	18
Hawke Bay, New Zealand	7 50	3	
Hawke Bay, Newfoundland	11 0	6	4
Heart's Content, Newfoundland	7 30	4	2½
Héaux Lights, France	5 45	31	23½
Heawandou Pholo Atoll, Maldives	9 30	5	
Heda Bay, Japan	. .	5½	
Helena St., Bay, Africa, West coast	2 30	6	
Helena St., Island, South Atlantic	3 11	3	
Helford, England	4 43	15½	11½
Helgoland, German Ocean	11 33	9½	
Helier, St., Jersey, English Channel	6 36	31½	23
Hellevoetsluis, Netherlands	2 30	5½	
Henry, Port, Patagonia, West coast	Noon	5	
Heppens, Germany	0 30	12½	
Hernando Island, Strait of Georgia, British Columbia.	6 0	12–14	
Hermite Isle, Australia, West coast	10 0	14	
Heron Islet, Capricorn Group, Australia, East c'st	9 0	10	
Herradura, Port, Chile	9 8	5	
Herradura, Nicoya Gulf	3 9	10	
Hervey Bay, Australia, East coast	9 14	10	
Hesquiat Harbor, Vancouver Island	Noon	12	
Hewett Bay, Tierra del Fuego	0 30	6½	
Heybridge, Blackwater River, England	0 20	12	8
Heynish, Tiree Island, Scotland	5 30	12	6
Hicks Bay, New Zealand	9 0	7	
Hie-chechin Bay, China, East coast	7 0		
Hi-ide, Japan	11 25	2–4	4½

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Hjerting, Jutland	2 45	4¾	
Highfield, America, Northwest coast	. .	16	
Hillsborough River, Charlottetown, Prince Edward Island.	10 45	9½	8
Hillsborough, (Head of River,) Prince Edward Is'd	11 0	10	7
Hillsborough Island, (New Port,) Bonin Islands	11 32	3½	
Hillswick Firth, Shetland	9 45	6½	5
Hiogo and Kobé Bay, Japan	7 15	5¾	4½
Hirtshals, Jutland	4 28	1	
Hoaksiel, Germany	Noon	11	
Hobarton, Tasmania	8 15	4½	3½
Hoe-e-tow Bay, China, East coast	2 15	16	
Hokianga River, (entrance,) New Zealand . .	9 45	10	
Hokianga River, (Kokohu,) New Zealand . .	10 15	10	7
Hokitika, (Bar,) New Zealand	9 39	8½–9	
Hollesley, England	11 30	8?	6?
Holmes Bay, America, Northwest coast . . .	1 0	13	10
Holsteinborg, Greenland	6 30	10	
Holy Island, England	2 30	15	11½
Holyhead, Wales	10 11	16	12½
Hon-cohe Bay, China Sea, West coast . . .	11 30	5	
Hondeklip Bay, Africa, Southwest coast . . .	2 30	5½	
Honfleur, France	9 29	23½	18
Honghai Bay, China, East coast	10 0	6½	
Honolulu, Sandwich Islands	4 0	2	
Hongkong, China, East coast	10 15	4¾	
Hoogly River, (Eastern channel light-vessel,) Bay of Bengal, West coast.	9 0	10¾	
Hoogly River, Diamond Harbor, Bay of Bengal, West coast.	Noon	12–15–18	
Hooper Island, Korea, South coast	9 10	11½	8½
Hope Harbor, Falkland Islands	8 10	7	
Hope Sound, (Mia-u-tau Group,) Yellow Sea .	10 24	6½	
Hope Weg Light, Germany	0 35	10½	
Hopedale, Labrador	5 38	7	4
Horn, Cape, Tierra del Fuego	4 40	9	
Horn or Blaavand Point, Jutland	1 44	5	
Horn Reefs, North Sea	Noon		
Horton Bluff, Bay of Fundy	0 30	48	40
Hougue, La, France	8 42	18½	14½
Hourdel, France	11 26	27½	21
Hout Bay, Africa, West coast	2 20	5	
Houtman Rocks, Australia, West coast . . .	11 30	2½	
Howden, River Tyne, England	. .	12	
Howe, West Cape, Australia, South coast . .	9 0	6	
Howth Harbor, Ireland	11 9	13	10
Huacho Bay, Peru	4 45	3	
Huafo Islands, Patagonia, West coast . . .	Noon	7	
Huapilinao Head, Patagonia, West coast . .	1 25	15½	
Huasco, Port, Chile	8 30	6	4
Huelva, Port, Spain	1 54	14	
Hui-ling-san, China, South coast	8 30	7½	
Huildad Inlet, Patagonia, West coast . . .	0 48	16–20	
Hu-i-tan Bay, China, East coast	12 15	16	
Hull, England	6 29	20¾	16½
Hull Bridge, Crouch River, England	12 25	16	11
Hulu Shan Bay, Yellow Sea	2 30	8	6

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Hungry Point, Australia, South coast	4 18	7	4–6
Hunter Island, Bass Strait	10 30	8	
Hunter, Port, Australia, East coast	9 45	6–7	
Hurst, (Camber,) England	10 0 and 12 0	7½	6
Husum, Denmark	2 20	9	
Icacos Point, Trinidad	4 14	7	4
Ichabo Island, Africa, West coast	1 0	6	4
Iengen, New Caledonia	6 15	4½	
Ilfracombe, England	5 42	27½	21½
Iki, Japan	. .	8	
Ilha Grande Bay, Paratio, Brazil	1 45	5½	
Ilheo, Port d', Africa, West coast	3 0	8–10	
Ilo-Ilo, Port, Filipinas	Noon	5½	
Inagua, Bahamas	8 0	3½	2½
Indefatigable Island, Galapagos	1 56	6	
Independencia Bay, Peru	4 50	4	
Indian Tickle, Labrador	6 37	6	4
Indio Point, South America, East coast	11 45	4	
Indus, (Gizree Bunder,) Hindoostan, West coast	9 50	7	
Inhambane River, Africa, East coast	4 15	10	
Inishbofin, Ireland	4 34	12½	9½
Inishkeel, Ireland	5 10	11	8
Inishturk, Ireland	4 36	12½	9½
Inkanskie, White Sea	9 15	14	
Inman, Cape, Tierra del Fuego	2 0	4	
Intsi Point, White Sea	11 55	16	
Inverary, Scotland	Noon	10	
Inverness, Scotland	0 18	12	9½
Investigator Road, Australia, North coast	8 0	9	
Iona Sound, Scotland	5 11	11¾	8¾
Ipswich, England	0 35	13½	
Iquiqui Road, Peru	8 45	5	
Ireland Island, Bermuda	7 4	4	
Isidro, St., Cape, Magellan Strait	1 0	8	
Island Harbor, Choiseul Sound, Falkland Isl'ds	5 20	6	
Island Country Harbor, Nova Scotia	7 40	6½	5½
Islay, Peru	8 53	7	
Isle-aux-Coudres, River St. Lawrence	4 25	17	10
Isles de Los, Africa, West coast	6 35	13	
Isthmus Bay, Smyth Channel	1 30	5	
Ives, St., England	4 44	21	15
Jacinto, San, Port Ticao Island, Filipinas	6 30	6	
Jackson, Port, (North Head,) Australia	8 15	6	
Jacmel, St. Domingo	Irregular	2–3?	
Jafrabad, Hindoostan, West coast	11 35	9	7
Jago, St., Bay, Magellan Strait	9 27	20	15
James Island, (Adam Cove,) Galapagos Islands	2 14	5	
James Island, (North side,) Galapagos Islands	2 34	5	
James Island, (West end,) Galapagos Islands	3 10	5	
Jashk Shoal, Persian Gulf	9 30	8	
Jask, Cape, Persian Gulf	6 0	6	
Jebogue, Bay of Fundy	10 4	15	11¼
Jedore, Nova Scotia	7 45	6½	4¾
Jekatarina Islands, Lapland	6 23	10	
Jerba, Mediterranean	3 10	7	5

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise.	
			Springs.	Neaps.
	h.	m.	Feet.	Feet.
Jericoacoara, Brazil	11	30	12	9
Jersey, (St. Helier,) English Channel	6	29	31½	23
Jersey, (Rosel)	6	15	30	21½
Jervis Bay, Australia, East coast	6	20	5	
Jezírat Arabí, Persian Gulf	6	30?		
Jezírat Hamar-al-nafur, Arabia, Southeast coast	9	30	10	
Jezírat Jún, Persian Gulf	11	30	10	
Jezírat Kabr, Persian Gulf	.	.	8½	
Jezírat Kais, Persian Gulf	0	45	7½	
Jezírat Kharg or Káreg, Persian Gulf	8	0	6½	
Jezírat Larek, Persian Gulf	10	15		
Jezírat Tumb, Persian Gulf	.	.	8	
Jiddah, Red Sea	.	.	3	
Jijginsk Island, White Sea	5	15	4	
Joao, San, Brazil	6	24	14	10½
Johanna Island, (anchorage)	3	40	11	
Johanna, Pomony Harbor, Comoro Islands	4	0	11	9
John, Port, America, Northwest coast	1	0	13	
John, St., Bay of Fundy	11	21	27	23
John, St., Newfoundland, East coast	7	30	6	4
John, St., Newfoundland, North coast	10	40	7½	5½
John, St., River, Africa, South coast	4	8	5¼	
Jones' Harbor, Newfoundland	7	49	3½	2
Jonquiere Bay, Gulf of Tartary	10	0	6	
Joombas River, Africa, West coast	8	10	6	
Josef, San, Port, Patagonia, East coast	10	0	30	25
Jourimain Island, New Brunswick	9	30	6	3
Juan de Nova, Madagascar	.	.	5	
Juan Fernandez Island, Chile	9	30	4	
Juan, San, Porto Rico	8	2	1½	
Juan, San, Port, Peru	5	10	3	
Juby, Cape, Africa	.	.	8	
Juggee, Seer River, Hindoostan, West coast	1	30	6	
Juist, Germany	10	28	6½	
Jukan Islands, Lapland	9	0	13	
Julian, San, Port, Patagonia, East coast	10	45	30	
Julianshaab, Greenland	5	6	7	5
Julien, St., Harbor, Newfoundland	7 6	21 a. m. 30 p. m.	4½	3
Junk Fleet Entrance, Canton River, China	11	50	6½	
Junk River, Africa, West coast	5	45	5	
Junkseylon Island, (East side,) Malacca Strait	10	0	11½	
Jura Island, (Small Isles,) Scotland	5	3	3½	2¼
Jura, Feolin Ferry, Scotland	4	41	6½	4¼
Juria, Hindoostan, West coast	2	0	16	13
Kaikora Penin, New Zealand	5	30	8	6
Kaipara Harbor, (entrance,) New Zealand	10	55	10	8
Kalang Bayang Harbor, Java	.	.	2	
Kalgalakska, White Sea	6	50	7	
Kalian Point, Banka Strait	8	0	12	
Kandalaksha, White Sea	3	25	7	
Kanushin, Cape, White Sea	11	54	15	
Kapiti Island, New Zealand	9	0	6	
Karáchi, Manora Point, Hindoostan, West c'st	10	30	7½	5½
Karakoa Bay, Hawaii	3	49		
Kata Channel, Japan	5	4	6½	

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Katwyk, Netherlands	2 30	5	7
Kawau Island, New Zealand	6 30	10	
Kawhia Harbor, New Zealand	9 30	12	
Keats, Port, Australia, North coast	6 0	22	
Kediwári River, Hindoostan	9 57	7	
Keelacarry, Ceylon	11 0		
Kedgeree, Bay of Bengal	10 30	18	
Keeling Islands, (Port Refuge,) Indian Ocean	5 30	5	
Kegashka Bay, Gulf of St. Lawrence	10 45	5	3
Kelung Harbor, (Formoza,) China Sea, East c'st	10 30	3	
Kenmare River, (West Cove,) Ireland	3 52	10	7½
Kenn Reef, Australia, East coast	8 0	5½	
Kent Group, Bass Strait	11 10		
Kentish Knock, England	11 47		
Keppel Bay, Australia, East coast	9 0	9–14	
Keret, White Sea	3 8	6	
Keret Point, White Sea	4 30	5½	
Kerguelen Island, Indian Ocean	2 0	2	
Kesm, Persian Gulf	11 0	12	
Khór Jerámeh, Arabia, Southeast coast	9 30	10	
Khôr as Shem, Persian Gulf	10 40	8½	
Khôr Rabbágy, Arabia, Southeast coast	10 10	9½	3
Kijouk Phyou Harbor, Bay of Bengal	10 0	9	6
Kilbaha, Ireland	4 16	13	9½
Kilda, St., Hebrides	5 30		
Kildin Island, Lapland	6 45	12	
Kilkieran Cove, Ireland	4 34	15½	11
Killala Bay, Ireland	5 22	10½	8
Killeany Bay, Arran Islands, Ireland	4 28	13½	10
Killingholme, (Humber River,) England	6 2	19¾	15½
Killybegs, Ireland	5 16	11½	8½
Killyleagh, Ireland	0 40	11	9½
Kilmichael Point, Ireland	8 30	4½	3
Kilrush, Ireland	4 42	14	10½
Kincardine, Firth of Forth, Scotland	2 53	17¾	15
King Island, Bass Strait, Franklin Road	1 0	7	
King Island, Bass Strait, Sea-Elephant Bay	9 30	12	
King, Port, Falkland Islands	7 30	5	
King Sound, Australia, West coast	0 10	33	
King George Sound, Australia, South coast.	11 56	1–4	
King's Cove, Newfoundland	7 15	3½	2½
Kingsbridge, England	5 46	10	
Kingston, Australia, South coast	0 6	5	
Kingstown, Ireland	11 10	11	8¾
Kinsale, Ireland	4 43	11½	9
Kinsiang Point, China, East coast	7 0		
Kircubbin, Ireland	0 42	11½	9½
Kirindi, Ceylon	3 30		
Kirkcudbright, Scotland	11 10	23	
Kirkwall, Orkneys	10 9	10	7½
Kirpon Harbor, Newfoundland	7 5	5	1¾
Kishm. (See Kesm.)			
Kiswara Harbor, Africa, East coast	4 30	12	
Kitnapatnam, Bay of Bengal, West coast	11 0	1½	
Kiu-kiang, China, West coast	. .	24	
Klaskino Inlet	Noon	12	
Klaskish Inlet, Vancouver Island	Noon	12	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Klemtoo Passage, America, Northwest coast	Noon	13	8
Klewnugget Inlet, America, Northwest coast	0 30	17	
Knox Bay, Vancouver Island	Noon	16	
Knysna Harbor, Africa, South coast	3 45	5	
Koelwatte Bay, Moluccas	. .	7	
Koepang, Timor	11 0	9	6½
Kokohu, New Zealand	10 15	10	7
Ko-kun-to Group, Korea	2 25	18	10
Kok-si-kon, Port, Formosa	11 30	3	
Koombanah Bay, Australia, West coast	9 0	½–3	
Kori or Lukput River, Kotasir, Hindoostan, West coast.	11 15	10½	
Kouloi River	1 15	20	
Kou Zomen, White Sea	3 30	6	
Kovda Bay, White Sea	3 25	6	
Koweyt, Persian Gulf	0 15	9	
Kowie River, Africa, South coast	4 0	4–5	
Krakatoa, Strait of Sunda	7 0	4	
Kúdi River, Hindoostan, West coast	9 50	10	
Kuper Harbor, Korea, South coast	9 28	11½	8½
Kuper, Port, America, Northwest coast	1 40	13	10½
Kuriyán Muriyán Bay and Islands, Arabia	8 20	6½	
Kurrachee. (See Karáchi.)			
Kutch, Gulf of, (mouth,) Hindoostan	11 30		
Kweshan Islands, China, East coast	9 30	14	
Kyau-chau Bay, Yellow Sea	5 0	12	9
Kyem River, White Sea	5 23	4	
Kykduin, Netherlands	7 0	12	
Kyle Akin, Loch Alsh, Scotland	6 16	15½	11
Kyle Rhea, Scotland	6 0	15	11
Kynumpt Harbor, America, Northwest coast	0 30	14	11
Kyuquot Sound, Vancouver Island	Noon	12	
La Poile Bay, Newfoundland	9 0	6	4
Labuan Island, Victoria Harbor, Borneo	9 45	6	
Labyrinth Islands, Magellan Strait	0 30	5½	
Lacul Harbor, St. Domingo	6 0?	3?	
Lady Bay, Australia, South coast	0 37	3	
Lady Elliot Islet, Australia, East coast	9 0	7–8	
Lagos, Portugal	2 7	13	
Lagos River, (Bar,) Bight of Benin	6 0	3	
Lagos River, (Consulate Wharf)	. .	2	
Lagos River, (Palaver Islands)	. .	1	
Laguimanoc, Port, Luzon	1 30	5½	
Laguna de Terminos, Gulf of Mexico	Noon	1½	
Lakadivh Group, Hindoostan, West coast	10 30	6	4½
Lamalin, Newfoundland	9 15	8½	
Lambayeque Road, Peru	4 0	3	
Lamlash, Scotland	11 49	10	7
Lamo Harbor, Africa, East coast	4 6	11	
Lancaster, England	11 16	8½	
Landshipping, Cleddau River, Wales	6 27	20	14½
Langeoog, Germany	11 25	8	
Langshan Crossing, Yang-tse-Kiang	1 40	12	8
Lankeet Island, Canton River, China	11 20	6½	
Lansew Bay, China, East coast	10 0	13	
Lanzarote, Canary Islands	1 0?	9?	

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise. Springs.	Rise. Neaps.
	h.	m.	Feet.	Feet.
Laredo Bay, Magellan Strait	11	30	9	
Largs, Scotland	11	50	10	
Lark Harbor, Newfoundland	10	37	5½?	
Latham Island, Africa, East coast	4	0	10	
Latitude Bay, Tierra del Fuego	2	5	4	
Lau-mu-ho, Yellow Sea	1	30	5	
Laun, Great and Little, Newfoundland	8	15	7	4
Laura Harbor, Tierra del Fuego	1	0	6	
Laurenny, Wales	6	23	20	14½
Lavata Bay, Chile	9	20	5	
Lawrence, Great St., Harbor, Newfoundland	8	30	7	4
Le Have, Cape, Nova Scotia	7	48	7	5¾
Le Have, Nova Scotia, Crooked Channel	7	51	7½	6
Le Have, Mother's Island	7	51	7	5¾
Le Have, Getson's Cove	7	55	7½	6
Le Have, Bridgewater, (McKean's Wharf)	8	6	8	6¼
Le Have, Lunenburg, (Spidler's Cove)	7	54	7½	6
Le Maire Strait, Tierra del Fuego	4	0	7	
Leervig Fiord, Færoe Islands	0	30	6¼	4½
Leith, Scotland	2	17	16½	12¾
Leman Shoal, England, East coast	6	c		
Lennox Cove, Tierra del Fuego	4	40	8	
Leopold, Port, Barrow Strait	0	6	6	4½
Lepreau, Bay of Fundy	11	18	24½	21
Lerwick, Shetland	10	30	6	4
L'Etang Harbor, Bay of Fundy	11	19	23½	20
Leubu River, Chile	10	30	5	
Leven, Port, Madagascar	3	30	7½	
Levrier Bay, Africa, West coast	Noon		6–7	
Lewis, St., Sound, Labrador	6	40	3½	1
Liant, Cape, Gulf of Siam, China Sea, West coast	5	7	6¼	
Liau Ho, (Bar,) Yellow Sea	4	0	11½	7½
Liau Ho, (entrance)	5	0	12	
Liau-tung, Chingho, Yellow Sea	1	20	6¼	
Liau-tung Gulf, (Sand Point,) Yellow Sea	4	50	7	5¾
Liau-tung, Northwest Head of Gulf	5	30	10	8¾
Liefkenshock	3	25	16¼	11½
Limbé Strait, Moluccas	.	.	5	
Limerick, Ireland	6	16	18¾	13¾
Linmouth, England	6	2	30½	21¾
Lindy River, (entrance,) Africa, East coast	4	15	12	
Lingeh, Persian Gulf	Noon?			
Lintin Island, Canton River, China, East coast	Noon		7½	
Lisbon, (Belem,) Portugal	2	30	12	9
Liscanor Bay, Ireland	4	23	13¾	10
Liscomb Harbor, Nova Scotia	8	0	6¼	4½
Lishan Bay, China, East coast	10	15	16	
Lissa, Adriatic	4	10	2½	
Listerdeep, Fairway Buoy, Denmark	0	30	5½	
Lister Roads	2	0	6¼	
Litau Bay, Yellow Sea	3	0	6	4
Litke Ridge, White Sea	11	45	15	
Little Fish Bay, Africa, West coast	2	30	5–6?	
Littlehampton, England	11	36	16	11½
Little Metis, Gulf of St. Lawrence	2	10	13	8
Little Milford Quay, River Cleddau, Wales	6	31	19	13½
Little Natashquan, Gulf of St. Lawrence	11	0	5	3

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise.	
			Springs.	Neaps.
	h.	m.	Feet.	Feet.
Little, Port, Newfoundland	10	42	5½	
Little Tancock Island, Nova Scotia	7	43	7¼	6
Liverpool, England	11	23	26	20½
Liverpool Bay, Nova Scotia	7	50	8	5
Liverpool River, Australia	6	30	12	
Liza Bay, Lapland	5	58	9	
Lizard Island, Australia, East coast	9	15	7–10	
Lizard Point, (Perran Vose Cove,) England	5	0	14¼	10½
Llanelly, (Bar,) Wales	6	16	25	18½
Lloyd, Port, Bonin Islands	6	8	3	
Loanda, San Paul de, Africa, West coast	4	30	5	
Loango Bay, Africa, West coast	4	30	6½	
Lobah Point, Banka Strait	11	0	10	
Lobito Bay, Africa, Southwest coast	4	15	5–6	
Lobo Point, Peru	8	0		
Lobos Cay, Bahamas	7	40	3	
Lobos Head, Patagonia, West coast	0	29		
Loch Aline, Scotland	5	33	13¾	10½
Loch Alsh, Scotland	6	16	15½	11
Loch Boisdale, Scotland	5	47	12¾	9½
Loch Broom, Scotland	6	40	14½	10½
Loch Carron, Scotland	6	29	16½	11½
Loch Cuan, Scotland	5	36	13	9½
Loch Duich, Scotland	6	0	15½	11
Loch Dunvegan, Scotland	6	7	15¼	11
Loch Eil, (Head of Loch,) Scotland	6	27		
Loch Eport, Scotland	6	6	12½	9¼
Loch Eriboll, Scotland	7	43	14¾	11
Loch Erisort, Scotland	6	43	15¼	11½
Loch Etive, Stonefield, Scotland	7	3		
Loch Etive, Bunawe, Scotland	7	54	5¾	
Loch Ewe, Scotland	6	39	14½	10½
Loch Fleet, Scotland	0	22	10¾	
Loch Goil, Scotland	0	6	10	6
Loch Harport, Scotland	5	54	13¾	10
Loch Hourn, Scotland	5	45	13¾	10¼
Loch Inver, Scotland	6	40	14	11
Loch Laxford, Scotland	6	44	15	11¼
Loch Leven, (Head of Loch,) Scotland	6	28		
Loch Linnhe, Scotland	5	26	12¼	8½
Loch Long, Scotland	0	6	12	
Loch Maddy, Scotland	6	6	12½	9¼
Loch Moidart, Scotland	5	44	13½	9¼
Loch Nevis, Scotland	5	47	14½	10
Loch Roag, Scotland	6	11	11	8
Loch Ryan, (Head of Loch,) Scotland	11	12	11	
Loch Skiport, Scotland	5	52	12½	9
Loch Strivan, Scotland	11	55	6	
Loch Sunart, Scotland	5	40	13½	
Loch Tarbert, West, Harris Island, Scotland	6	4	11¾	8½
Loch Tarbert, East, Harris Island, Scotland	6	10	13½	10
Loch Tarbert, West, Argyleshire, Scotland	2	30	1–4	
Loch Tarbert, East, Argyleshire, Scotland	11	53	9	
Loch Tongue, Scotland	7	53	15	12
Loch Torridon, Scotland	6	20	15	11
Loch Tuadh, Scotland	5	29	11¾	8
Lofoten Islands, Norway	Noon		9	7½

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Loheyyah, Red Sea	1 30	3	
Loire River, (St. Nazaire,) France	3 40	15½	11
Lomas Point, Peru	8 19	5	
Lombock, (Ampanam Bay,) Java Sea	8 0	6	
London Bridge, England	1 58	20¾	17½
London Docks, England	1 53	20¾	17½
Londonderry, Ireland	8 1	7¾	5½
Looe, (East,) England	5 26	16	13
Lopez, Cape, Africa	4 30	4–6?	
L'Orient, (Port Louis,) France	3 11	13	9½
Lord Howe Island, South Pacific	8 30	6	
Lorenzo, St., Channel, Mexico, West coast	8 30	6	
Lo-shan-kau, Yellow Sea	4 30	11	9
Lough Larne, Ireland	10 48	6¾	6½
Lough Rossmore, Ireland	5 20	11	8
Louis, Port, France	3 11	13	9½
Louis, Port, Mauritius	0 30	3	2½
Louis, St., Bay, St. Domingo	Irregular	2–3?	
Louisburg Harbor, Cape Breton Island	8 0	5	4
Low Bay, Falkland Islands	5 0	5½	
Low Inlet, America, Northwest coast	0 30	17	15
Low, Port, Patagonia, West coast	0 40	7	
Lowestoft, England	9 57	6½	5½
Laubo River, (entrance,) Africa, East coast	. .	22	
Lucipara Pass, Banka Strait	Irregular	10	7½
Lukput, Kori River, Hindoostan, West coast	0 15	12	
Lunaire Bay, St., Newfoundland	7 6	5	2¾
Lundy Island, England	5 15?	27	20
Lung-mun Harbor, Yellow Sea	10 0	7	
Lyme Regis, England	6 21	11¾	8½
Lymington, England	{10 25 / 0 15}	8	6
Lynn Deep, England	6 0	23	
Lynn Harbor, England	. .	22½	
Lynn Road, England	. .	23½	
Lytteltou, Port, New Zealand	3 50	7½	5½
Mabou River, Cape Breton Island	9 0	4	
Macahé, Brazil	2 30	9½	
Macao, China, East coast	10 0	6½	
Macassar, Celebes	4 40	5½	
McDougall Harbor, Africa, Southwest coast	2 30	5¾	
McLaughlin Bay, Northwest coast of America	1 0	14	10
Maceio, Brazil	4 30	8½	
Machias, Seal Island, Bay of Fundy	11 5	18	14¾
Macowa, Red Sea	0 30	2	
Macquarie Harbor, Tasmania	7 30	3	
Macquarie, Port, Australia, East coast	8 56	4–5	
Macquereau Point, Gulf of St. Lawrence	2 0	5	3
Madame Island, Madagascar	4 0	5	
Madoc, Port, Wales	7 30	17	
Madras Road, Coromandel coast	7 34	3½	
Magadoxa, Africa, East coast	4 30	8	
Magdalen Islands, Gulf of St. Lawrence	8 20	3	2
Magdalen River, River St. Lawrence	1 15	6–8	3–4
Magdalena, Santa, Island, Magellan Strait	Noon	10	
Magdalene Bay, California	7 35	6¾	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise.	
			Springs.	Neaps.
	h.	m.	Feet.	Feet.
Mahato Island, Africa, East coast	4	30	7	
Mahneah River, Africa, West coast	7	40	11	
Mahone Bay, Nova Scotia	8	0	7	
Mahone Bay, Heckman's Anchorage	7	45	7½	6
Mahone Bay, Prince's Inlet	7	42	7½	6
Mahone Bay, Ham Island	7	47	7½	6
Mahone Bay, Martin's River	7	43	7½	6½
Mahone Bay, Chester	7	44	7	5¾
Mai Island, New Hebrides	6	30	5	
Maiden Rocks, Ireland, Northeast coast	10	43	6¼	6¼
Maiko, Fort, Japan	6	27	3½	1
Majambo Bay, Madagascar	4	30	16	
Makâtein, Arabia, Southeast coast	9	0	6	
Makelleh, Arabia, Southeast coast	8	30	7	
Makongai Island, Fiji Islands	6	0	4	3
Makumba River, Madagascar	4	45	17	
Makung Harbor, Pescadres, China Sea	10	30	9½	7
Malabrigo, Port, Peru	5	0	2	
Malacca Strait, (light-vessel, One Fathom Bank)	6	0	15	12
Malacca Strait, (off Mount Formosa)	8	0	11	8½
Malacca Road, Malacca Strait	7	30	11	8½
Malaga, Spain	Noon		3	
Malahide Inlet, Ireland	11	15	10	8
Malcolm Atoll, Maldives	10	30	3	
Maldon, Chelmer River, England	0	32	10	6
Malè, Maldives	0	30	3	
Malludu Bay, Borneo	10	30	6–8	
Malo, St., France	6	5	35	26
Malpelo Point, Peru	4	0	10	
Man-of-War Cay, Bahamas	8	10	4	
Mana Island, New Zealand	7	0	8	6
Manama, Persian Gulf	5	20	7	
Manawatu River, New Zealand	10	0	8	6
Mancenilla Bay, St. Domingo	7	0	4–5	
Mandwa Creek, Hindoostan, West coast	10	45	7	5
Mangalore, Hindoostan, West coast	11	0	7	5½
Manganitoe Bay, Moluccas	5	0		
Mangarol Bunder, Hindoostan, West coast	10	30	7	5
Manicouagon River, River St. Lawrence	2	15	12	7
Manila, (Luzon Island,) China Sea, East coast	10	40	3½–6	
Manning River, Australia, East coast	9	15	4	
Manorah River, Hindoostan, West coast	1	30	16	
Manta, Port, Ecuador	3	4	6	
Manau, Navigators Islands	.	.	6	
Manukau Harbor, (entrance,) New Zealand	9	30	13	10
Manybranch Harbor, Falkland Islands	7	40	7½	
Maple Bay, Vancouver Island	.	.	12	
Maplin Light, (Thames,) England	0	5	14½	10½
Maquereau Point, Gulf of St. Lawrence	2	0	5	3
Maracas Bay, Trinidad, Caribbee Island	3	30	5	4
Maranham, Brazil	7	0	16½	10¾
March Harbor, Tierra del Fuego	3	10	6	
Marcouf, St., France	9	55	20	
Mare Harbor, Falkland Islands	6	0	6	
Margarets, St., Bay, (Shut-in Island,) Nova Scotia	7	47	7½	6
Margarets, Newfoundland	9	28	4½–6½	
Margate, England	11	40	15½	13

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise.	
			Springs.	Neaps.
	h.	m.	Feet.	Feet.
Maria, Cape, Saghalin Island, Sea of Okhotsk	2	0	5	
Maria, Santa, Island, Chile	10	20	6	
Maria Van Diemen, Cape, New Zealand	8	0	7	
Marion Bay, Australia, South coast	2	6	4	
Maristow, River Tavy, England	5	47	8½	4½
Marjoribanks Harbor, Korea, West coast	3	30	29	
Mark, St., Bay of, St. Domingo	8	0?	1?	
Marka, or Muerka, Africa, East coast	4	30	8	
Maroni Bay, Comoro Islands	4	53	10	
Maroni River, Guayana	5	30	8	6
Martaban, Bay of Bengal	2	20	21	
Martin, St., Cove, Tierra del Fuego	3	30		
Martin, St., Cove, Cape Horn Islands, Tierra del Fuego.	3	50	8	
Martin, St., de la Arena, Spain, North coast	3	30	15	
Martin Vas Rocks, South Atlantic	3	45		
Martinique, Robert Harbor, Carribbean Sea	.	.	4-5	
Mary, Cape, St., Newfoundland	8	30	7	5
Mary, St., Harbor, Madagascar, East coast	4	0	5	
Mary, St., Harbor, Newfoundland	7	40	7½	5
Mary, Port, St., Isle of Man	11	10	20	16
Mary, St., Scilly Islands	4	18	15¾	11¾
Maryport, England	11	3	18	13
Mascat, Persian Gulf	11	15	6	
Mason Bay, New Zealand	11	10	8	6
Massacre Bay, (Tasman corner,) New Zealand	8	45	13	9
Massacre Bay, Motu Pipi River, New Zealand	9	50	14	10
Massowah, Red Sea	1	0	3	
Matan River, Gulf of St. Lawrence	2	15	11	7
Matoya Harbor, Japan	6	50	6	1½
Matuku, Fiji Islands	6	18	5	3
Maule River, Chile	10	0	5	
Maullin River, Chile	0	30	8	
Maulmain, Bay of Bengal	2	0	22	17
Mauritius, (Port Louis)	0	30	3	2½
Mauritius, (Grand Port)	1	0	1½	
Mayday Bay, Palawan	9	55	3½	
Mayhé Island, Indian Ocean	4	0	6½	
Mayne Harbor, Smyth Channel	1	40	6	
Mayotta Island, Mozambique	4	10	11½	
Mayumba, Africa, Southwest coast	4	35	7	
Mazambo, Port, Madagascar	4	30	15	
Mazatlan, Mexico, West coast	9	40	7	
Mbau Roads, Fiji Islands	5	46	6	
Mboli Harbor, Florida Island, Solomon Islands	5	30	About 6	
Meichen Sound, China, East coast	0	30	17	
Melbourne, Australia, South coast	2	48		
Melinda, Port, Africa, East coast	4	15	11	
Mellacoree River, Africa, West coast	7	40	11	
Mellish Reef, (Sand Cay,) Australia, East coast	7	55	5-6	
Mellon, Ireland	6	1	18½	13¾
Melo, Port, Patagonia, East coast	3	40	15	
Memory Rock, Bahamas	7	50	3	
Menadou Bay, Cape Breton Island	8	15	5½	
Menam River, (Paknam,) China Sea, West coast	5	7	9½	
Mensular Island, (Southeast end,) Sumatra	6	0	4	
Merbát, Arabia, Southeast coast	9	0	6¾	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Mercy Bay, Banks Land	. .	2	
Mercury Bay, New Zealand	7 21	7	5
Mergui, Bay of Bengal, East coast	10 30	18	
Merigomish, Nova Scotia	10 6	5½	3½
Merville, France	9 36	21	17½
Metalanim, Port, Caroline Islands	4 20	3–4½	
Metlahcatlah, America, Northwest coast	Noon	21	
Metway, Port, Nova Scotia	7 50	8	5
Mevagizey, England	5 4	15½	12
Mexillones, Port, Bolivia	10 32	3	
Mezen, White Sea	1 48	15–22	
M'hul Dwarka, Hindoostan, West coast	10 30	7	
Miau-tau, (Depôt Bay,) Yellow Sea	10 35	6	
Miaveness, Færoe Islands	3 12	6½	4½
Michael, St., Azores	12 30	6	
Michael Seymour, Port, Gulf of Tartary	5 30	3	
Middle Cove, Tierra del Fuego	3 30		
Middle Island, Patagonia, West coast	Noon		
Middlesbrough, River Tees, England	3 55	13	10½
Middleton River, Bight of Benin	4 15	5	
Middleton Reef, South Pacific	8 30	6	
Midway Island, North Pacific	3 13	3	
Miguelon Road	8 33	3½	
Mikuni Roads, Japan	. .	2	
Milford Haven, (St. Ann Light-house,) Wales	5 56	24	18
Milford Sound, New Zealand, Middle Island	9 15	8	6
Millman Island, Palawan, West coast	10 27	2¾	
Millport, Cumbrae Island, Scotland	11 50	10	6
Min River, (Temple Point,) China, East coast	10 27	18	13
Min River, (Losing Island,) China, East coast	Noon	17	14½
Mindanao, South Point, Filipinas	7 0	6	
Minehead, England	6 24	32½	24½
Mingan Harbor, Gulf of St. Lawrence	1 16	6	4
Mingan Island, Gulf of St. Lawrence	1 30	6	4
Minimegash, Prince Edward Island	3 30	5	3
Minow Islands, Madagascar, West coast	5 0	15	
Minquiers Rocks, France	6 6	35	26
Miramichi, (Bar,) Gulf of St. Lawrence	5 30	5	3
Mira-por-vos, Bahamas	9 30	3	2½
Mirs Bay, (Tide Cove,) China, East coast	10 0	6½	
Miscou, Gulf of St. Lawrence	2 30	5	3
Mistanoque, Labrador	10 30	6	3
Mistley Quay, Stour River, England	0 48	11¾	
Miwara, Japan	10 37	11	5
Moala, Fiji Islands	5 50	5	
Mocha Island, Chile	10 30		
Mocha Road, Red Sea, East coast	Noon	4½	
Moerdijk	4 0	9	
Mogador, Africa, West coast	1 18	10–12	
Molyneux Bay, New Zealand	3 0	8	6
Mombaza, Port, Africa, East coast	4 0	11	
Monach Islands, Scotland, West coast	5 44	12½	8½
Monckton, (Railway,) Bay of Fundy	0 15	47	37½
Mondego, (Bar,) Portugal	2 30	7	
Monganui Harbor, New Zealand	8 15	9	7
Monrovia, Africa, West coast	6 0	6	
Montagu, South Australia, East coast	8 30	5–7	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Neaps.
	h. m.	Feet.	Feet.
Monte Video, South America, East coast . .	. .	4–6	
Montgomery Isles, Australia, West coast . .	Noon	36	
Montrose, Scotland	1 25	13	10
Monts, Point de, Gulf of St. Lawrence . . .	Noon	12	6
Montt, Port, Reloncavi Sound, Chile	0 48	18–20	14–15
Morecambe, England	11 26	27	21
Moreno, (Constitucion Road,) Peru	10 0	4	
Moreton Bay, Australia, East coast	9 30	4–7	
Morewellham, River Tamar, England . . .	6 12	10½	6½
Morjovets Island, White Sea	11 20	17	
Morlaix Road, France	4 53	24	18
Morro, (Sandy Point,) Ecuador	5 0	11	
Mossel Bay, Africa, South coast	3 30	6	
Moudiuga Island, White Sea	5 50	3½	
Mount Louis Bay, River St. Lawrence . . .	2 0	6–8	4
Mourondava, Madagascar, West coast . . .	4 45	12	
Mouton, Port, Nova Scotia	7 54	7½	5¾
Moville, Ireland	7 6	7½	5½
Mowah Bunder, Hindoostan, West coast . .	1 0	12	9½
Mozambique Harbor, Africa, East coast. . .	4 15	12	
Mucaras Reef, Bahamas	7 40	3	
Muerka. (See Marka.)			
Mugeres Harbor, Bay of Honduras	9 30	1½	
Mull of Cantyre, Scotland	10 35	4	
Mulroy Bay, (Bar,) Ireland	5 40	11¾	8
Mumbles Light-house, Wales	6 1	27½	20½
Mungalaum Island, China Sea, East coast . .	11 0	5	
Mongullo or Mongallo River, Africa, East coast	4 45	12	
Murray Islands, Torres Strait	9 30	10	
Musa, Port, Babuyan Islands	. .	5	
Mutlah River, (entrance to Biddah River,) Bay of Bengal, West coast.	10 0	14	
Mutlah, (Muda Kali,) Bay of Bengal, West coast	11 45	15	
Mutton Island, Ireland, West coast	4 20	13¾	9½
Myggenæs Fiord, Færoe Islands	9 0	9½	7½
Na Vatu Reef, South Pacific	6 8	4	
Naafe River, Bay of Bengal, East coast . . .	10 0		
Naalsoe Fiord, Færoe Islands	4 0	6½	4½
Nafa-Kiang, Loo Choo Islands	6 28	7	
Nagasaki Bay, Japan	7 15	9	7½
Nagore, Bay of Bengal, West coast	8 15		
Nairai Island, Fiji Islands	5 53	3½–4½	
Namki Islands, China, East coast	8 30	17	
Namoa Harbor, China Sea, West coast . . .	10 0	7½	
Namoa Island, (Clipper Road,) China, East coast	11 15	7	
Namquan Harbor, China, East coast	10 0	17	
Namu Harbor, America, Northwest coast . .	. .	15	12½
Nanaimo Harbor, Gulf of Georgia, Vancouver Island.	5 0	14	
Nancowry Harbor, Nicobar Islands	9 15	8½	
Nandi Passage and Bay, South Pacific . . .	6 35	4½	
Nangamessie Harbor, Sumba	11 30	17	13½
Nangka Island, Banka Strait	. .	12	
Nanoose Harbor, Vancouver Island	5 0	15	
Napoleon Road, Gulf of Tartary	2 30	2½	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Narrinda Bay, Madagascar, West coast	4 30	15	
Narrows, (First,) Magellan Strait	9 0	36–42	
Narrows, (Second,) Magellan Strait	10 0	23	
Naruto, (Fukura,) Japan	6 14	6½	2
Nash Point, Bristol Channel	6 25	33	25
Nasparte Inlet, Vancouver Island	Noon	12	
Nass Bay, America, Northwest coast	1 5	23	
Nassau, New Providence, Bahamas	7 30	4	3
Nassau Bay, Tierra del Fuego	4 0	6	
Natal, Port, Africa, South coast	4 30	6	
Naturaliste Channel, Shark's Bay, Australia, Northwest coast.	11 45	6	
Navallo, Port, France	3 42	13	9¾
Nazaire, St., France	3 40	15½	11
Naze, The, England	0 6	12½	10
Neath, England	6 16	13½	
Needle's Point, England	9 46	7½	5
Negapatam, Bay of Bengal	5 0	3	
Negro Harbor, Nova Scotia	8 12	7	5¾
Negro River, Patagonia	11 0	14	
Nelson, New Zealand	9 50	14	10
Nelson, Port, Australia, Northwest coast	Noon	27	
Nemoro Anchorage, Japan	5 0	4	2½
Nempkish River, Vancouver Island	0 30	14	
Nerbudda River, (Broach Point,) Hindoostan, West coast.	3 40	25	
Neuf, Port, Gulf of St. Lawrence	2 10	13	8
Neuf, Port, River St. Lawrence	8 30	14	9
Neuharlinger Siel, Germany	11 45	5¾	
Neuzen or Terneuse, North Sea	1 35	15	11
Neville, Port, Vancouver Island	0 30	17	
New Providence, Southwest Bay, Bahamas	7 30	4	
New Perlican Harbor, Newfoundland	7 30	4	2½
New River, New Zealand	0 10	8	6
New Ross, Ireland	6 4	12½	10
New Year Sound, Tierra del Fuego	8 30		
Newcastle, Australia, East coast	9 0	3½–5	
Newcastle, England	4 23	10½	
Newcastle, Ireland	11 4	14¾	12
Newhaven, England	11 51	20	15
Newport, Wales, South coast	7 10	38	29
Newport, Wales, West coast	7 0	12	9
New Quay, Wales	7 30	15	
Newton Stewart, Carty Quay, Scotland, West coast.	Noon	12	6
Ngaloa, Fiji Islands	6 0	5	
Nhatrang Bay, China, West coast	8 30	6	
Nicholas, St., Harbor, Gulf of St. Lawrence	1 55	12	7
Nicholas, St., Port, Peru	5 15	3	
Nicholson, Port, (Lambton Harbor,) New Zealand.	4 30	5	3
Nicobar Island, (Nancowry Harbor,) Indian Ocean,	9 15	8½	
Nicolas, St., Bay, Magellan Strait	0 50	6	
Nicoya Gulf, (Port Herradura,) Central America	3 9	10	
Nieuport, Belgium	0 18	16	13
Nieuwediep, Netherlands	7 27	4	

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Niger River, (Nun entrance,) Africa, West coast	4 8	6	
Nikolskoi Channel, White Sea	5 25	3	
Nikolskoi Tower, White Sea	6 0	2	
Nimrod Sound, China, East coast	10 30	20	
Ninepin Group, China, East coast	10 0	5	
Ning-hai, Yellow Sea	Noon	6	
Nin-po-fu, Yung River, China, East coast . .	1 0	9	
Nisqually, America, Northwest coast . . .	6 0	18	15
Noamh Island, Scotland	5 2	11½	7
Noarlunga, Port, Australia, South coast . . .	4 30	6	
Noel Bay, Bay of Fundy	0 41	50½	43½
Noir Island, Tierra del Fuego	2 30	5	
Noirmoutier, France	3 2	16	11¼
Nolloth, Port, Africa, Southwest coast . . .	2 35	5¼	3½
Nootka Sound, Vancouver Island	Noon	12	
Norderney, Germany	11 15	7¾	
Nore, England	0 30	15½	13
Norfolk Island, South Pacific	7 45	7	
North Balabac Strait, China, East coast . . .	10 50	5	
North Cape, Cape Breton Island	8 0	4	
North Harbor, Newfoundland	8 0	7½	5
North Sands, Malacca Strait	5 30	15	12
Nosari Khari, (Bar,) Hindoostan, West coast .	3 0	18	
Noss Island, Madagascar	5 0	15	
Notske Bay, Japan	4 50	4½	1½
Noumea Bay, New Caledonia	8 25	4	
Nova Zembla Harbor, Lapland	6 36	10	
Novogorod Bay, Korea	2 30	2½	
Nowanugga, Hindoostan, West coast . . .	1 45	18	14
Nuchatlitz Inlet, Vancouver Island	Noon	12	
Nuevo Gulf, Patagonia, East coast	7 0	10	
Nuevo, Port, Central America	3 10	12	
Nukulau, Port, Fiji Islands	6 47	3½–5	
Numa-choa, Comoro Islands	3 0	14	
Nunez River, Africa	10 0	15	11½
Nyminde Gab, Jutland	2 45	2½	
Nysna or Knysna Harbor, Africa, South coast .	3 30	6–7	
Oazy Harbor, Magellan Strait	10 18	7	6
Oban, Scotland	5 22	12	9½
Obb of Harris, Isle of Harris, Scotland . . .	6 16	11½	8½
Observatory Inlet, America, Northwest coast .	1 5	23	12
Observatory Island, China Sea, East coast . .	11 0	5¼	
Octavia Bay, New Granada	3 30	13	
Oelar, Cape, Banka Strait	6 30	12	
Ogden Channel, America, Northwest coast . .	1 0	20	
Oho Sima, Loo Choo Islands	7 30	5½	
Oibo Harbor, Africa, East coast	4 15	6	
Okarito Lagoon, New Zealand	11 40	9	
Old Providence, Bay of Honduras	Irregular	1	
Olenji Islands, Lapland	7 30	12	
Oleron, Isle d', France	3 50	19	
Olga Bay, Gulf of Tartary	5 30	3	
Omaider Island, Gulf of Akabah, Red Sea . .	6 0	4	
Omersari River, Hindoostan, West coast . .	1 45	18	
Omonville, France	7 29	15¼	12½
'Om-rasas-Masfrah, Arabia, Southeast coast .	10 0	10	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
One-Fathom-Bank Light, Malacca Strait	6 0	15	12
Onega River, White Sea	9 17	6–7	
Ono Islands, South Pacific	6 0	4	
Ooloogan Bay, China Sea, East coast	9 30	5½	
Oonting, Port, Loo-Choo Islands	6 35	8	
Oōsaka River, (entrance,) Japan	7 30	5¾	4¾
Oōsaka City, Japan	8 17	2½	½
Oōsima, Japan	6 50	5	4
Oōsuka, Japan	9 16	8¼	1½?
Oparo or Rapá Island, Ahurei Bay, South Pacific	Noon	1–2	
Oporto, Portugal	2 30	10	
Orange Bay, Tierra del Fuego	3 30	5	
Orange, Cape, Magellan Strait	3 0		
Orete. (See New River.)			
Orford Haven, (Bar,) England	11 30	7½	
Orford Quay, England	0 30	7½	
Orfordness, England	11 15	8	6½
Orinoco River, (entrance,) Guayana	6 0	3	
Orleans Island, River St. Lawrence	5 40	17	13
Ormond, Kenmare River, Ireland	3 43	10	7½
Ornsay, Isle of Skye	5 50	14¾	10½
Orlov Letni, Cape, White Sea	5 18	4	
Os Ilheos, Brazil	4 30		
Osaki, Japan	5 55	6¼	
Oscuro Cove, Patagonia, West coast	0 55	20	
Osprey Reef, Australia, East coast	8 36	6	
Ostend, Belgium	0 25	19	15
Otago Harbor, New Zealand	2 50	7	5
Otaheite, South Pacific	Noon	1¼	
Otterswick, Orkneys	9 13	11	8
Otway, Port, Patagonia, West coast	11 37	6	
Ou-ou Kinsh Inlet, Vancouver Island	Noon	12	
Ounalashka Island, America, Northwest coast	7 30	7½	
Ouro River, Africa, West coast	Noon	8–9	
Ovalau, Fiji Islands	6 0	3–5	
Owasi, Japan	7 0	5	2
Ower Shoal, England, East coast	6 30		
Oxbaasheia, Svee Fiord, Norway	Noon	8	
Oystreham, France	9 38	21	16
Packsaddle Bay, Tierra del Fuego	3 30	6	
Padstow, England	5 13	20½	16½
Pagham, (entrance,) England	11 30	16½	12½
Pago Pago, Navigator's Islands, South Pacific	7 11	3½	
Paimpol, France	6 0	31	23½
Palais, Port le, Belle Isle, France	3 18	14½	10½
Palliser, Cape, New Zealand	6 0	6	
Palm Isles, Australia, East coast	. .	8–10	
Palma, Canary Islands	0 30?	9?	
Palmas, Cape, Africa, West coast	4 30	4	
Palmedo Road, Sumba Island	. .	15	
Palmeira Point, Ceylon	9 30	7–11	
Paluan Bay, Mindoro	. .	5	
Pamarung Islands, Borneo, East coast	. .	8–10	
Pampang Bay, Java	. .	7–8	
Panama Road, Central America	3 23	15–22	10–16
Panbula River, Australia, East coast	9 0	4–6	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Pancol, China Sea, East coast	9 40	6	
Pansand Hole, England	Noon	15½	13
Paposo, Chile	9 40	5	
Paquique, Cape, Bolivia	9 45		
Para, Brazil, North coast	Noon	11	
Parahiba, Brazil	5 0	9–12	
Paranagua, Brazil	3 0?	6½	
Parenga-renga Harbor, New Zealand	7 54	7	
Parida Island, New Granada	3 15	10½	
Parsboro, Bay of Fundy	0 17	43	37½
Pasado, Cape, Ecuador	3 30	10	
Pasages, Port, Spain	3 0	12	9
Passage or Culebra, Port, Caribbean Sea	9 0	1	
Passage Island, Banda Sea	Noon	6	
Passandava Bay, Madagascar, West coast	5 0	15	
Paterson's Inlet, New Zealand	1 10	5	6
Patterson, Port, Australia, North coast	4 0	13–20	6–12
Patrick, Port, Scotland	11 10	15	12
Patta Bay, Africa, East coast	4 30	10	
Patteson, Port, Vanu Lava Island, Banks Isl'ds	6 40	5	
Patytan Bay, Java	3 0	7	
Paul de Loanda, San, Africa, Southwest coast	4 30	5	
Paul, St., Island, Indian Ocean	11 0	3	
Paul, St., Island, Gulf of St. Lawrence	8 0	5	3
Paumben Pass, Bay of Bengal, West coast	1 30	2	
Payta, Port, Peru	3 20	3	
Pearce Point, Australia, North coast	6 55	20	26
Pecket Harbor, Magellan Strait	9 30	7	6
Pedro Gonzales, Trapichi Island, New Granada	3 50	16	
Pedro, San, Pass, Patagonia, West coast	0 30	9	
Peejow. (See Pidioe.)			
Peel, Isle of Man	11 8	16½	13
Pegasus, Port, New Zealand	11 50	8	6
Peh-tang-ho, Yellow Sea	3 33	10	7½
Pei-ho or Peking River, (entrance,) Yellow Sea	3 40	10	7½
Pei-ho or Peking River, (Tien-tsin)	7 0	4½	
Pelew Islands, North Pacific	. .	6	
Pelican Lagoon, Kangaroo Island, Australia	5 0	6	
Pelorus Sound, New Zealand	9 35	11	7
Pellworm, Denmark	1 50	10	
Pemba Channel, Mozambique	4 0	11	
Pemba Island, Mozambique	4 15	12	
Pembroke Dockyard, Wales	6 12	21	15½
Penang, Malacca Strait	Noon	9	7
Peñas, Cape, Tierra del Fuego	6 2	12	
Pender Harbor, Strait of Georgia, British Columbia.	6 0	13	
Peniche, Portugal	1 54		
Penmarch Rocks, France	3 16		
Pennington River, Bight of Benin	4 15	5	
Pentillie, River Tamar, England	5 55	13½	9½
Pentland Firth, Stroma, South side	9 47	7½	6
Pentland Firth, Swona, East side	10 24		
Pentland Firth, Swona, West side	9 35		
Pentland Firth, Great Skerry, East side	11 4	7½	6½
Pentland Firth, Great Skerry, West side	10 53		
Penzance, England	4 30	16½	12½

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Percy Isles, Middle or No. 1 Island, Australia, East coast.	10 30	16	13
Percy Isles, South or No. 2 Islet, Australia, East coast.	10 30	14	
Perim Island, Gulf of Aden	Noon	7	5½
Pernambuco, Brazil	4 45	8–6	
Peros Banhos, Indian Ocean	1 30	5	
Perouse, La, Strait, Japan	10 30	6	
Perron, Cape, Shark's Bay, Australia, Northwest coast.	0 45	5½	
Perth, Scotland	3 35	9½	
Perula Bay, Mexico, West coast	. .	7	
Pescadore Islands, (Makung Harbor,) China Sea	10 30	9½	7
Peter, St., Bay, Cape Breton Island	7 30	6	4
Peter, St., Harbor, Prince Edward Island . .	8 30	4	2½
Peterhead, Scotland	0 34	10¾	8½
Petit Passage, Bay of Fundy	10 41	22	18
Petit, Port, Bay of Islands, Newfoundland . .	10 42	5½	
Petrel Bay, St. Francis Isle, Australia, South coast.	Noon	6	
Petucura Rock, Patagonia, West coast . . .	0 50	16	
Pheasant Point, Wusung River, China, East coast.	0 35	13	8
Philip Bay, East side, Magellan Strait . . .	9 30	24	
Philip, Port, Lonsdale Point, Australia, South coast.	9 42	7	5½
Philip, Port, Queen's Cliff, Australia, South coast.	10 50	3	2
Philip, Port, Nepean Point, Australia, South coast.	10 53	2¾	1½
Philip, Port, Dromana, Australia, South coast .	2 19	3	2½
Philip, Port, Schnapper Point, Australia, South coast.	2 14	2¾	2
Philip, Port, Bellarine Jetty, Australia, South coast.	2 21	2½	2
Philip, Port, Harvey Point, Australia, South coast.	2 39	3	2½
Philip, Port, Geelong, Australia, South coast .	2 30	3½	2½
Philip, Port, Williamstown, Australia, South c'st	2 31	2¾	2
Philip, Port, Melbourne, Australia, South coast	2 48		
Pichidanque Bay, Chile	9 20	5	
Pictou Harbor, Nova Scotia	10 0	6	4
Pidioe or Peejow Bay, Lombock	. .	10–12	
Piedras Cay, Cuba	8 0	2½	
Piel Harbor, England	11 5	28	21
Pierre Strait, Newfoundland	8 33	6½	4½
Pierre Island, China Sea, East coast	. .	4	
Pigeon Bay, Yellow Sea	11 45	8	
Pihkishan Islands, China, East coast	8 30	17	
Pillar, Cape, Magellan Strait	1 0		
Pillar, Cape, Tasmania	1 0	6	
Pillars, River St. Lawrence	5 0	17	10
Pimlea Harbor, Africa, East coast	4 30	12	
Pinas Bay, New Granada	3 15	14	
Ping Yang River, Korea	7 45	21	14
Pinmill, Orwell River, England	0 20	12	
Pio Quinto, Port, Babuyan Islands	6 0	6	

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Pirie, Port, Spencer Gulf, Australia, South coast	7 15	9–11	
Pisco Bay, Peru	4 50	4	
Piti Palena, Patagonia, West coast	0 23	10	
Piti River, Hindoostan, West coast	10 5	9	
Placentia, Newfoundland	9 15	8	
Plank Point, Spencer Gulf, Australia, South c'st	6 15	6–8	
Playa de Incia, Cuba	7 31	2½	
Playa Parda Cove, Magellan Strait	1 8		
Pleasant, Port, Falkland Islands	5 0	6½	
Plettenberg Bay, Africa, South coast	3 10	6	
Ploughrescan, France	5 17	25½	18¾
Ploumanach, France	5 15	24½	18½
Plumper Cove, Howe Sound, Gulf of Georgia, British Columbia.	Noon	12	
Plumper Sound, (Fane Island,) Vancouver Isl'd	Irregular	12	
Plymouth Breakwater, England	5 37	15½	11¼
Plymouth, (Sutton Pool,) England	5 32	15½	11½
Plymouth, New, New Zealand	9 30	12	9
Pomba Bay, Africa, East coast	4 0	15	11
Pomeroy Inlet, Labrador	6 20	7	4
Pomquet, Nova Scotia	9 15	4	2½
Ponapi Island, Caroline Islands, North Pacific	3 0	6	
Ponga River, Africa, West coast	7 30	12	9½
Poolbeg Light-house, Ireland	11 12	12–14	9–11
Poole, England	9 10 and 0 45	6½	4¾
Poolewe, Loch Ewe, Scotland	6 39	14½	10½
Pools Harbor, Newfoundland	7 0	4	3
Pootoo Island, China, East coast	8 15	12	
Poqueldon Harbor, Patagonia, West coast	0 54	18	
Portaferry, Ireland	Noon	18–21	12–16
Port-au-Choix, Newfoundland	10 47	5	
Port-au-Prince, St. Domingo	8 0?	1?	
Port-en-Bessin, France	8 57	20	15½
Port Macdonnel, Australia, South coast	0 2	4	
Port Pola, (Adriatic)	9 16	3½	
Port Rhin, Mulgrave Islands, Marshall Islands	5 0	6½	
Port Royal, Jamaica	11 0	1	
Port Spain, Trinidad, Caribbee Islands	4 30	4	3
Portchester, England	11 46	13½	10½
Portendik, Africa, West coast	10 0	6	
Porthcawl, Wales	6 8	28½	21½
Porth-dyn-lleyn, Wales	8 30	16	
Portishead, England	7 13	40	31
Portland Bay, Australia, South coast	0 30	3 irr.	
Portland Breakwater, England	7 1	6¾	4½
Porto Frio, Brazil	2 40	4½	
Porto Praya, St. Jago, Cape Verde Islands	6 0?	5	
Porto Santo Bay	0 50	7	
Portree, Isle of Skye	6 32	15	10¾
Portrieux, France	6 0	31	23½
Portsbridge, (Portsmouth,) England	11 48	6½	4
Portsmouth Dockyard, England	11 41	12¾	10
Possession Bay, Magellan Strait	8 35	36–42	
Possession, Cape, Torres Strait	9 0	6	
Possession Island, Torres Strait	1 0	9½	
Post-Office Island, (Charles Island,) Galapagos Islands.	2 10	6	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Post-Office Island, Torres Strait	1 0	9½	
Poulamente Bay, Madame Island, Cape Breton Island.	7 50	6	4
Poulton-le-Sands, England	11 26	27½	21½
Poverty Bay, New Zealand	6 5	6	
Pratas Shoal, China Sea	4 0	5	
Preservation Inlet, New Zealand	11 20	8	4
Preston, England	11 49	10	4½
Prince Frederick Harbor, Australia, Northwest coast.	Noon	28	
Prince Regent River, (St. George Basin,) Australia, Northwest coast.	0 20	24–37	
Prince of Wales Strait, Banks Land	. .	3	
Prince's Island, Bight of Biafra	3 45	4½	
Princess Royal Harbor, Australia, South coast .	11 56	1–4	
Prospect River, Nova Scotia	7 43	7	6
Pubnico, (Beach Point,) Bay of Fundy . . .	9 25	12	10
Puerto Bueno, Patagonia, West coast . . .	0 24	8	
Puerto de Baitiqueri, Cuba	9 7	2½	
Puerto de la Luz, Gran Canaria, Africa, West coast.	0 52	10	
Puerto de Maravi, Cuba	7 56	2½	
Puerto de Mata, Cuba	6 49	2¾	
Puerto de la Plata, St. Domingo	7 30	3?	
Puerto de Taco, Cuba	8 49	2¾	
Puget Sound, (Nisqually,) America, Northwest coast.	6 0	18	15
Pugwash Harbor, Nova Scotia	10 30	7	4
Pulicat Shoals, Coromandel coast	9 25	2¾	
Pulo Aor, Sumatra, Northeast coast	. .	5	
Pulo Condore, China Sea, West coast . . .	2 30	6½	
Pulo Leat, Gaspar Strait	2 30	4	
Pulo Mendanao, Gaspar Strait	2 30	4	
Pulo Panjang, Gulf of Siam	7 0	2	
Puluqui Island, Patagonia, West coast . . .	1 5		
Puna Island, Ecuador	6 0	11	
Pwlheli, (Bar,) Wales	7 46	13¾	9¾
Qlawdzeet Anchorage, America, Northwest c'st	1 30	17–22	14–17
Quaco, Bay of Fundy	11 35	30	25
Quan-chow-wan, Gulf of Tongking	. .	9–10	
Quatsino Sound, Vancouver Island	11 0	11	
Quebec, River St. Lawrence	6 38	18	13
Queda, Malacca Strait	Noon	5½	
Queen Charlotte Sound, (entrance,) New Zealand	8 50	8	6
Queensferry, Firth of Forth, Scotland . . .	2 37	18	14
Queenstown, Ireland	5 1	11¾	9
Quelan Cove, Patagonia, West coast	0 28		
Quentin, San, Port, California	9 5	9	
Queullin Island, Chile	. .	20	
Quicavi Bluff, Patagonia, West coast . . .	0 57	20	
Quilca River, Peru	8 0	6	
Quilimane River, (entrance,) Africa, East coast .	4 15	16	
Quilleboeuf, France	10 6	9½	7½
Quiloa, Africa, East coast	4 45	12	
Quoile Quay, Strangford, Ireland	0 45	11	9¼

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Rabat, Africa, West coast	1 46	9–12	
Race, Cape, Newfoundland	7 0	6½	5
Rachada, Cape, Malacca Strait	5 30	13	
Radama, Port, Madagascar, West coast	4 40	13	
Ragged Island, Sumbawa, Java Sea	8 10	3	
Ragged Point, Borneo, East coast	. .	7	
Raine Island, Torres Strait	8 10	10	
Rajang River, Borneo	4 45	13	9
Rajapur River, (entrance,) Hindoostan, West coast.	11 0	9	7
Rajapur River, (town,) Hindoostan, West coast	0 20	7	
Rajpuri River, (entrance,) Hindoostan, West c'st	10 40	11	6
Ramos River, Bight of Benin	4 20	5	
Ramree Road, Bay of Bengal, East coast	10 0	12	
Ramsay Sound, Wales	6 0	17	
Ramsey, Isle of Man	11 12	19½	16
Ramsgate, England	11 44	15	12
Ramso Fiord, Norway	10 45	7	
Random Head Harbor, Newfoundland	7 8	3½	2½
Rangoon, Bay of Bengal, East coast	5 30	21	14
Rangoon River, (entrance,) Bay of Bengal, East coast.	3 15	21	14
Raoul or Sunday Island, South Pacific	6 0	5	
Rás Haffin, Africa, East coast	6 15	4	
Rás Jerdaffoon. (See Guardafui Cape.)			
Rás Madraka, Arabia, Southeast coast	9 0	10	
Rás Sharmah, Arabia, Southeast coast	9 0	8	
Rás-el-Khaimeh, Persian Gulf	11 45	7	
Rás-al-Asídah, Arabia, Southeast coast	8 30	5½	
Rás Shébali, Arabia, Southeast coast	10 0	10	
Rás-al-Hed, Arabia, Southeast coast	9 30	9	
Rathmullan, Ireland	5 42	12½	9
Ratna-ghiri, Hindoostan, West coast	10 30	8	6½
Realejo, Central America	3 6	11	
Red Bay, Ceylon, South coast	2 20	2½	
Red Bay, (Pier,) Ireland	10 31	4	4
Red Bay, Labrador	7 45	3½	1½
Red Island, Durian Strait	5 0	10½	
Redbridge, England	10 42 and 0 57	8½	6
Refuge Cove, Bass Strait	0 5	8	
Régneville, France	6 20	35	26
Reikiavik, Iceland	5 0	17½	13½
Reloncavi Inlet, Patagonia, West coast	0 44	14	
Rendezvous Island, Borneo, Southwest coast	. .	8	
Rendezvous, Strait of Georgia	7 0	14	
Renfrew, River Clyde, Scotland	1 15	9	
Resolution Bay, Marquesas	2 30	4	
Resolution, Port, Tanna Island	5 35	3	
Reunion Island, (St. Pierre,) Indian Ocean	Noon	3½	
Reunion Island, (St. Denis,) Indian Ocean	0 22	2½	
Reunion Island, (St. Gilles,) Indian Ocean	1 0	2½	
Reunion Island, (St. Paul,) Indian Ocean	1 7	4	
Rewa Road, Fijii Islands. (See Nukulau Port,)			
Rhio, Rhio Strait	9 50	7	5
Ribble Light-house, England	10 51	24	17
Richibucto River, Gulf of St. Lawrence	3 30	4	2½
Richmond Harbor, Prince Edward Island	6 0	3	2

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Richmond River, Australia, East coast	9 20		
Rio de la Plata, Cape Castillos	8 30	2	
Rio de la Plata, Buenos Ayres	Noon	3–5	
Rio de la Plata, Barragan Bay	7 0	5–9	
Rio Grande do Sul, Brazil	. .	1½–2	
Rio Janeiro, Brazil	3 0	4	3
Rio Negro, Patagonia, East coast	11 0	14	10
Rio Nunez, Africa, West coast	10 0	15	11½
Ristegouche River, Campbelltown, Gulf of St. Lawrence.	4 0	10	7
Rivadeo, Spain, North coast	3 0	15	
Rivoli Bay, Australia, South coast	0 33	4	
Rocas, Atlantic	5 15	10	
Roche, Cape, River St. Lawrence.	9 30	6	4
Roche Harbor, Haro Strait.	Irregular	12	
Rochefort, France	4 6	17	13
Rochelle, France	3 31	17	13
Rockall, North Atlantic	3 30	12	
Rocky Island, Gulf of Siam	4 0	4	
Rodney Bay, Owasi, Japan	7 0	5½	2
Rodrigue Island, Indian Ocean	1 45	6	
Roebuck Bay, Australia, West coast	0 30	30	18
Roji, Hindoostan, West coast	1 40	18	14
Romania Point, (Malay Peninsula,) China Sea, West coast.	10 30	12	9
Romdals Islands, Norway	10 45	6	
Rona (South) Light, Scotland	6 20	14½	10¾
Roodewall Bay, Africa, Southwest coast	2 30	6½	
Roque, St., Cape, Brazil	. .	10	8
Roscoff, France	4 46	3	17½
Rosel, Jersey, English Channel	6 15	30	21¼
Roshnoff, Cape, America, Northwest coast	7 30	15	
Rosslari Point, Ireland	6 30	5	3½
Rota, Spain	1 24	12½	8
Rotterdam, Netherlands	3 45	7	
Rottnest Island, Australia, West coast	7 50	2½	
Rottum, Netherlands	10 0	7½	
Rouen, France	2 28		
Rouge Harbor Newfoundland.	7 0?	6	4
Roundstone, Ireland	4 28	13¾	10½
Rovama River, Africa, East coast	4 0	16	11½
Royal Harbor, Ruatan, Bay of Honduras	7 45	3½	
Royal Island, Bahamas	7 45	3½	
Royal Road, Strait of Magellan	9 47	8	
Royalist, Port, Palawan, East coast	11 0?	6½?	
Royan, France	3 38	13½	10
Ruapuke Island, (Foveaux Strait,) New Zealand.	1 0	8	6
Rugged Island, Bahamas	8 0	3	
Rugged Island, Nova Scotia	7 59	7½	6
Ruggles Bay, Falkland Islands	7 30	5	
Rupon, Hindoostan, West coast	10 30	10	7
Rush, Port, Ireland	6 8	5½	3½
Rutland Island, Ireland, West coast	5 22	11	8
Ryde, England	11 20	13½	
Rye Bay, England	11 20	22	17½

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise.	
			Springs.	Neaps.
	h.	m.	Feet.	Feet.
Sable, Cape, (Clam Point,) Bay of Fundy	8	27	8½	6½
Sable, Cape, (Clarke's Harbor,) Bay of Fundy	8	58	11	9
Sable Island, (North side,) Nova Scotia	7	30	4	
Sable Island, (South side,) Nova Scotia	6	30	4	
Sables d'Olonne, Les, France	3	26	14	10
Sabon Island, Durian Strait	.	.	10	
Sacred Bay, Newfoundland	7	23	2½	
Sacrificios, Port, Mexico, West coast	3	15	6	
Saddle Island, East, China, East coast	11	0	14	
Sado, (Yebisu,) Japan	5	0	2	
Safety Cove, America, Northwest coast	1	0	14	11
Sagitsu-no-ura, Japan	8	0	9	
Saguenay, Chicoutimi, Gulf of St. Lawrence	4	11	12	8
Saguenay, Tadousac, Gulf of St. Lawrence	2	45	17	10
Saïgon, Cape St. James	2	30	12½	
Saïgon, (Saïgon City,) Cochin China	4	30	12	
Saintes, Caribbean Sea	6	45		
Saipan Island, Ladrone Islands	6	45	2½	
Sal, Cape Verde Islands	7	45	5	
Salango Island, Ecuador	0	41	12	
Salcombe, England	5	41	15	11½
Saldanha Bay, Africa, West coast	2	30	5	3½
Salee River, Boisee Island, Korea	5	20	36½	16–27
Salm River, Africa, West coast	8	10	6	
Salmedina Rocks, Spain	1	27	12½	8
Salomon Islands, South Pacific	6	45	2	
Saltash, River Tamar, England	5	45	15	11
Salt Cay Anchorage, Bahamas	8	15	4	3
Saltees, St. George's Channel	5	40		
Salut Isles, Brazil	4	26	6–10	
Salvador, San, Port, Falkland Islands	8	10	8	
Samana Bay, Hayti	9	30?	3?	
Samanco Bay, Peru	6	30	2	
Sambilangs, Malacca Strait	.	.	12	10½
San Bento River, Africa, West coast	4	30	5	
San Blas, Patagonia	1	30	12	10
San Blas, Mexico, West coast	9	41	6½	
San Fernando, Trinidad	4	36	5	3
San Juan del Sur, Central America	3	8?	10?	
San Juan River, New Granada	6	0	12	
San Lucar, Spain	1	53	12½	8
San Miguel, California	9	25	5	4
Sanboronbon Bay, South America, East coast	10	45	6	
Sandalwood Bay, Fiji Islands	6	0	6?	
Sand Point, Gulf of Liautung, Yellow Sea	4	50	7	5½
Sandwich, Port, Malicollo Island, New Hebrides	5	30	4	
Sandy, Cape, Australia, East coast	8	50	6–8	
Sandy Cove, East, Bay of Fundy	10	33	21½	17½
Sandy Cove, West, Bay of Fundy	10	47	23	19
Sandy Island, Madagascar, West coast	5	0	15	
Sandy Islet, Australia, West coast	10	35	18	
Sandy Point Road, Magellan Strait	Noon		5	4
Sang-tau Bay, Yellow Sea	0	55	7	4½
Sanguianga, (entrance,) Ecuador	4	10	9	
Sanguir Island, Moluccas	.	.	6	
Sangwin River, Africa, West coast	5	15	4	
Sanmoon Bay, St.George Island,China,East coast	10	20	15	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise.	
			Springs.	Neaps.
	h.	m.	Feet.	Feet.
Sannana Bay, Moluccas	.	.	9	
San-Shui, Si Kiang, China, East coast	.	.	5–6	
Santa Catalina Island, California	9	35?	5?	4?
Santa Cruz River, Patagonia, East coast	9	30	40	29
Santa Cruz, or Agadir, Africa	0	45	9	
Santa Cruz Islands, South Pacific	4	50	4–5	
Santa Cruz Island, California	9	35?	5?	4?
Santa Cruz, Teneriffe, Canary Islands	1	30	8	
Santa Maria Island, Chile	10	20	6	
Santander, Spain	3	30	15	12
Santiago de Cuba, Cuba	8	30	2	
Santoña, Spain	3	30	12½	10½
Saparooa Island, Moluccas	.	.	6	
Sapetiba Bay, Brazil	2	0	5½	
Sapie Bay, Sumbawa	1	0	10	
Sarawak River, (Moratabas entrance,) Borneo, West coast.	4	0	9	5½
Sarawak River, (Santubong entrance,) Borneo, West coast.	4	0	10	6
Sarawak River, Sarawak Junction, Borneo, West coast.	5	0	15–18	9
Sarawak River, Sarawak City, Borneo, West coast	5	20	15–18	9
Sarmiento Bank, Magellan Strait	8	10	36–42	
Sarn Badrig, or the Causeway, Wales	7	30	13	
Sarn-y-Bwch Reef, Wales	7	40	14	
Sau-o Bay, Formoza	5	50	6	4½
Saugor Island, Bay of Bengal	10	0	12	6–9
Saumarez Reef, Australia, East coast	8	0	6	
Scales Point, Blackwater River, England	Noon		14½	10
Scalloway, Shetland	9	30	5½	4½
Scapa, Orkneys	9	5	10	7½
Scarborough, England	4	11	15½	12½
Scarborough Shoal, Filipinas	11	0	5	
Scarcies Rivers, Africa, West coast	7	10	10	
Scarnish, Tiree Island, Scotland	5	31	12	9
Schiermonnikoog, Netherlands	9	40	5½	
Schooner Retreat, Northwest coast of America	0	30	14	11
Scilly Islands, (St. Agnes Island,) England	4	30	16	12
Scilly Islands, (St. Mary Island,) England	4	18	15½	11½
Scilly Islands, (Trescow,) England	4	22	16½	12½
Sea Bear Bay, Patagonia, East coast	0	45	20	
Seaforth, Loch, Athline, Scotland	6	16	15	10
Seaham, England	3	24	14½	10½
Seal Cove, Grand Manan, Bay of Fundy	10	54	20	15
Seal Island, Cape Sable, Bay of Fundy	9	49	12½	10½
Seamount Bay, Mulroy Bay, Ireland	6	44	7½	
Sebastian, San, Brazil	2	0	4	
Sebastian, San, Tierra del Fuego	7	0		
Sebastian, San, Spain, North coast	3	0	12	9
Sebastian, San, Bay, Africa, South coast	3	8	6	
Sedashigar Bay, Hindoostan, West coast	10	0	6½	5
Seer River, Hindoostan, West coast	10	30	11	
Seer River, Juggee	1	30	6	
Segoro Wedie Bay, Java	9	0	8	10
Sein, Chausèe de, France	3	21	17½	12
Seldom-come-by, Newfoundland	7	13	4½	3
Seleney Bay, Lapland	7	9	9	

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise. Springs.	Neaps.
	h.	m.	Feet.	Feet.
Selsea Bill, England	11	45	16½	12½
Semiahmoo Bay, Gulf of Georgia, Amer., Northwest coast.	2	0	12	
Senegal, (Bar,) Africa, West coast	8	42	6	
Senegal, (Guet N'dar,) Africa, West coast	8	42	6	
Senegal, (St. Louis,) Africa, West coast	10	0	6	
Séoul River, (Po-teu-mai,) Korea	7	20	16½?	
Séoul River, (Séoul,) Korea	9	30	6½	
Serraia, Hindoostan, West coast	1	0	16	13
Serrana Bank, Mosquito coast	.	.	2	
Serranilla Bank, Mosquito coast	Irregular		2	
Sesham Islands, Hang-chu Bay, China, East coast	11	45	14	
Setubal, Portugal	2	30	11½	7
Seudre River, (entrance,) France	3	31	15	
Seurin, St., France	4	11	14½	11
Seychelle Archipelago, (Mayhé Isd,) Indian Ocean	4	0	6½	
Seymour Narrows, British Columbia	4	0	11	
Seypan Island. (See Saipan.)				
Seven Islands, Lapland	8	20	12	5
Seven Islands Bay, Gulf of St. Lawrence	1	40	9	
Sha-lui-tien Banks, (west part,) Yellow Sea	2	50	10	8
Sháb Kadún, Arabia, Southeast coast	9	20	10	
Sháb'bu-saifeh, Arabia, Southeast coast	9	45	10	
Shalbet Island, Hindoostan, West coast	Noon		9	7
Shallow Harbor, Falkland Islands	9	30	6	
Shanghai, Yang-tse-Kiang, China, East coast	0	40	10	7
Shao-king, Si Kiang, China, East coast	.	.	3	
Sharja, Persian Gulf	1	0	6	
Sharks Bay, Naturaliste Channel, Australia, Northwest coast.	11	45	6	
Sharks Bay, Denham Sound, Australia, NW. coast	0	5	5	
Sharks Bay, Freycinet Reach, Australia, NW. coast	3	0	5	
Sharks Bay, Freycinet Estuary, Australia, Northwest coast.	4	15	3½	
Sharks Bay, Cape Perron, Australia, NW. coast	0	45	5½	
Sharks Bay, Hamelin Pool, Australia, NW. coast	5	0	3½	
Sharpness, England	7	58?	28?	15?
Shediac Harbor, New Brunswick	1 0 and 8 0		4	2
Sheephaven, Ireland	5	32	11½	8½
Sheerness, England	0	37	16	13½
Sheet Harbor, Nova Scotia	8	6	6½	4½
Shefeen Island, Africa, South coast	4	40	12	
Shelburne, Nova Scotia	8	4	7	5½
Sheldrake Island, Gulf of St. Lawrence	6	0	5	3
Sherbro River, Africa, West coast	7	50	6	5
Shields, North, England	3	23	13½	10
Shihtau Bay, Yellow Sea	1	30	9	7
Ship Harbor, Nova Scotia	7	54	6½	4½
Ship Harbor, (New Island,) Falkland Islands	10	30		
Shippigan, Gulf of St. Lawrence	3	42	5½	3
Shoal Bay, Australia, North coast	6	0	18–25	10–15
Shoal Bay, East coast	8	30		
Shoal Water Bay, Australia, East coast	10	30	12–18	
Shoalhaven River, Australia, East coast	8	30	6–9	
Sholl Bay, Smyth Channel	11	45	6	
Shoreham, England	11	34	18	13½
Shushartie Bay, Vancouver Island	.	.	12	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise. Springs.	Rise. Neaps.
	h.	m.	Feet.	Feet.
Si Kiang, or West River, (San-shui,) China, East coast.	.	.	.	5–6
Si Kiang, or West River, (Shao-king,) China, East coast.	.	.	.	3
Si Kiang, or West River, (Wuchan,) China, East coast.	.	.	.	1–1½
Siak River, Malacca Strait	9	0	12	
Siak River, (off the town)	.	.	11	
Sidili River, China Sea, West coast	9	44	7	
Sidmouth, Cape, Australia, East coast	9	15	10	
Sierra Leone, Africa, West coast	7	55	8	
Sillabar River, (Bar,) Sumatra	6	0	4½	
Simidsu, Japan	7	30	7	
Simoda, Japan	5	0	3–5	
Simonoseki, Japan	8	30	8	6
Simons Bay, Africa	2	44	5½	3¾
Simpson, Port, Northwest coast of America	1	30	17–22	14–17
Singapore, New Harbor, Malacca Strait	9	45	10	7½
Singoteer Mata, Hindoostan, West coast	5	20	24	
Sinou, Africa, West coast	5	0	4	
Sir C. Hardy Islands, Torres Strait, East coast	9	15	10	
Sir E. Pellew Islands, Australia, North coast	7	30	4–7	
Sisal, Gulf of Mexico	.	.	2	
Sitka, America, Northwest coast	0	34	12	8
Siyako Island, Japan	0	16	9½	4
Skaapen Fiord, (between Stormö and Sandö,) Faroe Islands.	5	0	9½	7½
Skaapen Fiord, (between Hestö and Sandö,) Faroe Islands.	5	30	9½	7½
Skagen, or the Skaw, Jutland	5	56	1	
Skerry, Great, (East side,) Pentland Firth	11	4	7¾	6½
Skerry, Great, (West side,) Pentland Firth	10	53		
Skerries, Ireland, North coast	6	15	5	3
Skerries, Ireland, East coast	11	0	13	10
Skidegate Inlet, Queen Charlotte Islands	1	0	17	14
Skip Ness, Scotland	11	50	9	
Skull, Ireland	4	2	9¾	7½
Slaughden, Orford, England	1	0	7½	
Slievebane Bay, Ireland, West coast	5	49	10½	7¾
Sligo Bay, (Mullaghmore,) Ireland	5	18	11½	8½
Sligo Harbor, Ireland	5	23	11½	8½
Sluissche-gat, North Sea	0	50	14¾	10
Slyne Head, Ireland, West coast	4	30	13½	10
Smalls Light-house, St. George's Channel	6	0	21	
Smerwick, Ireland	3	50	11½	8
Smith Sound, Newfoundland	7	8	3½	2½
Smoky Bay, Australia, South coast	0	15	6	
Smyth Harbor, Tierra del Fuego	Noon		6½	
Snape Bridge, Orford, England	3	0	6	
Snapper Point, Australia, South coast	4	40	8½	5–7
Socoa, France	3	19	12½	8¾
Society Bay, (Sulivan Bay,) Yellow Sea	0	15	8	
Socotra Island, Indian Ocean	7	20	8	
Sofala River, Africa, East coast	4	0	19	
Solitary Islands, Australia, East coast	9	15	5	3
Solomon Islands, Indian Ocean	1	30	5	
Solovet Road, White Sea	5	0	4	

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Sonderho, Fanö, Denmark	2 22	5½	
Sooke Harbor, Vancouver Island	2 0	8	
Soonmianee Harbor, Persian Gulf	9 0	9?	
Sosnovaia Bay, White Sea	2 40	6	
Sosnovets, White Sea	11 44	18	
Souma, White Sea	6 30	5½	
Sourabaya Strait, Java	Irregular	4–6	
Sourabaya Strait, (Jansen Channel,) Java	Irregular	8½	
South Rock, Ireland	10 58	13	10½
Southampton, England	10 30 and 0 45	13	9½
Southwest Bay, New Providence	7 30	4	
Southwest Cape, New Zealand	Noon	7	5
Southerness, Scotland	11 20	28	
Southwold, England	10 20	6½	4½
Spain, Port, Trinidad	4 30	4	3
Spaniards Bay, Newfoundland	7 45	4½	3
Spencer Bay, Africa, West coast	10 50	5–6	
Spenser's Anchorage, Bay of Fundy	11 42	39	33
Spencer Gulf, (Thorny Passage,) Australia, South coast.	Noon	6–8	
Spencer Gulf, (Point Lowly,) Australia, South coast.	7 0	6–8	
Spencer Gulf, (Port Augusta,) Australia, South coast.	8 30	9–12	
Spencer Gulf, (Point Riley,) Australia, South c'st	5 45	4½	
Spencer Gulf, (Wallaroo,) Australia, South c'st	5 45	4–5.	
Sphax Roads, Mediterranean	4 30	5	3
Spicers Cove, Bay of Fundy	11 35	37	30½
Spider Island, China, East coast	10 0	17	
Spiekeroog, Germany	11 30	8½	
Spitzbergen, (Bell Sound)	8 56	3½	
Spitzbergen, (Danes Sound)	0 24	5½	
Spurn Point, (Humber River,) England	5 26	18¾	15
Staten Island, Tierra del Fuego	4 30	8	
Staunton Island, Yellow Sea	1 30	8	5½
Stephens, Port, Australia, East coast	8 30	6	4
Stephens, Port, Falkland Islands	7 45	7½	
Stewart, Harbor, Tierra del Fuego	2 50	4	
Stirling, (Firth of Forth,) Scotland	3 52	7½	4½
Stirrup Cays, Bahamas	7 0	4	
Stockton, (Tees,) England	4 40	11	
Stonefield, (Loch Etive,) Scotland	7 3		
Stonehaven, Scotland	1 10	14	11
Stornoway, (Lewis Island,) Scotland	6 46	13	9½
Strangford, (Killard Point,) Ireland	10 53	14	11½
Strangford, (Quay,) Ireland	0 31	10½	8¾
Strangford, Head of Lough, (Turley Rocks,) Ireland.	0 44	11½	9½
Streaky Bay, (Blancheport,) Australia, South coast	1 0	5	
Stroma, (South side,) Pentland Firth	9 47	7½	6
Stromness, Orkneys	9 0	10	7½
Stuart Channel, (Oyster Harbor)	6 0	10	
Stuart Channel, Cowitchin Harbor, Vancouver Island.	. .	10–12	
Stuart Island, Strait of Georgia	6 0	12–14	
Suadiva Atoll, Maldives	1 0	4	
Sual, Port, Luzon	. .	6	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Suderõ Fiord, Faroe Islands	6 0	9½	7½
Suez Bay, (head of Gulf,) Red Sea	11 0	7	4
Sughrá, Arabia, Southeast coast	8 0	6	
Sumburgh Head, Shetland	9 45		
Sunday, or Raoul Island, South Pacific	6 0	5	
Sunderland, England	3 22	14½	11
Sunderland, North, England	2 30	15	11½
Supé Bay, Peru	4 50	3	
Surat, (entrance,) Hindoostan, West coast	2 45	19	15
Surat, (town,) Hindoostan, West coast	4 0	19	
Surge Narrows, Strait of Georgia	6 0	12	
Surinam, Guayana	6 0	9–10	5–6
Sussex, Port, Falkland Islands	8 15	6	
Sutton Pool, England	5 32	15½	11½
Sviatoi Nos, Lapland	9 15	14	
Svinõ Fiord, Faroe Islands	Noon	6½	4½
Swain Reefs, Australia, East coast	10 25	10	
Swallow Bay, Strait of Magellan	1 17	5	
Swan Island, Tasmania	9 35	6	
Swan Point, Australia, West coast	0 10	26	
Swan River, Gage Road, Australia, West coast	8 50	2½	
Swan River, Port Grey, Australia, West coast	9 0	1–1½	
Swansea, (Mumbles Light-house,) Wales	6 1	27½	20½
Swatau, China, East coast	3 0	9	
Swift Bay, Australia, North coast	Noon	18	
Swona, (East side,) Pentland Firth	10 24	10	7½
Swona, (West side,) Pentland Firth	9 35	10	7
Sydney, Australia, East coast	8 38	4½	4
Sydney Harbor, Cape Breton	9 0	5	4
Ta-tsing ho, Yellow Sea	4 10	10½	8
Table Bay, Africa, West coast	2 40	5	3½
Taboga, New Granada	4 0	14	
Tabou River, Africa, West coast	4 45	3–4	
Tabuai Island, South Pacific	. .	3	
Tadeo, San, River, Patagonia, West coast	11 45	6	
Tahiti, South Pacific	Noon	1½	
Tahrí, Persian Gulf	5 0?		
Tai-cho ho, Yellow Sea	0 15	6	
Taichow Islands, China, East coast	9 0	14	
Tai-Tai Bay, China Sea, East coast	9 30	5½	
Takush Harbor, British Columbia	1 0	14	11
Talcahuano, Chile	10 14	5	
Talcan Island, Patagonia, West coast	1 3	15½	
Tailung Channel, Canton River, China	1 30	6½	
Ta-lien-whan Bay, Yellow Sea	10 47	10½	8
Tama no Ura Harbor, Goto Island, Japan	8 40	6–8	4–6
Tam-Sui Harbor, China Sea, East coast	11 45	7–10	
Tamar River, (Georgetown,) Tasmania	0 5	10	7½
Tamar River, (Launceston,) Tasmania	1 0	12½	.
Tamar, Port, Magellan Strait	1 40	6	
Tamatave, Madagascar, East coast	4 18	8	
Tanabé, Ki Channel, Japan	6 0	6	5½
Tanera, Summer Islands, Scotland	6 37	14	10½
Tangier, Africa, North coast	1 42	8½	5
Tangtang Harbor, Madagascar, East coast	4 30	6	
Tanjong Api, China Sea	. .	7	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Tanjong Bolus, Malacca Strait	9 30	10½	½
Tanna, New Hebrides	5 35	3	
Tappanoely Harbor, Sumatra	6 10	6	
Taranaki, or New Plymouth, New Zealand	9 30	12	9
Tarbert, Ireland	4 57	14½	10½
Tarifa, Spain	1 46	6	3½
Tarn Point, Solway, Scotland	11 22	23	18
Taské, Japan	9 44	8½	1½?
Tatamagouche, Nova Scotia	10 0	8	5
Tatiyama Bay, Japan	5 50	5	
Ta-tong River, Korea	6 30	13	
Tauranga Harbor, New Zealand	7 10	6	4½
Tavoy River, (entrance,) Bay of Bengal, East coast.	10 30	20	
Tay River, (Bar,) Scotland	2 6	16	14
Tay-bay-oo-bay, China Sea, East coast	10 15	6	
Teavarua Harbor, Raiatea Islands, South Pacific.	Irregular	1	
Teboncas Road, Baly, North coast	5 0	6½	
Teelin Harbor, Ireland	5 16	11½	8½
Tees River, (Bar,) England,	3 45	15	12½
Teignmouth, England	6 0	13	9½
Tellicherry, Hindoostan, West coast	11 40	5	4
Tenby, Wales	5 42	27	20
Tenerife, Cape, Verd Islands, (Santa Cruz)	. .	8½	6
Terceira, Azores	0 32	4½	
Teriberka River. Lapland	7 20	12	
Teremakau River, New Zealand	9 55	9	
Terneuse, or Neuzen, North Sea	1 35	15	11
Terschelling, (West,) Netherlands	8 40	6	
Tetrina, White Sea	3 17	7	
Tetuan, Africa, North coast	2 23	2½	1½
Texel, (Outside Shoals,) Netherlands	6 30	4	3½
Thirsty Sound, Australia, East coast	10 45	12–18	
Thomas, St., Island, Africa	3 25	4½	
Thompson Sound, New Zealand	11 30	8	6
Thorny Passage, Spencer Gulf, Australia, South coast.	12 0	6–8	
Thorsminde, Jutland	3 34	2	
Three-Hummock Island, (East side,) Bass Strait	11 30	10	
Three Kings Islands, New Zealand	8 0	7	
Three Points, Cape, Africa, West coast	4 0	4	
Three Rivers, River St. Lawrence	11 30	1	
Thurso, Scotland	8 28	13½	9½
Ticao Island, (Port San Jacinto,) Filipinas	6 30	6	
Tictoc Bay, Patagonia	1 45	11	
Tien-pak Harbor, China, East coast	Noon	8½	
Tilly Bay, Strait of Magellan	1 30	6	
Tinghae, Chusan, China, East coast	11 0	12	9
Tobago, Caribbean Sea	3 0	4	2
Tobermory, Isle of Mull	5 36	13	9½
Toboe Ali Point, Banka Strait	8 30 and 10 0	10–12	
Toboolchi Bay, Saghalin Island	4 16	3	
Tomo, (Inland Sea,) Japan	11 0?	.	5
Tongatabu, South Pacific	6 50	6	
Tongsang Harbor, China, East coast	11 30	12	
Tönning, Germany	1 55	11½	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise. Springs.	Rise. Neaps.
	h.	m.	Feet.	Feet.
Toona, Gulf of Kutch, Hindoostan	1	50	16	13
Tooniang Island, (Bias Bay) China, East coast.	8	0		
Toorbut Point, Australia, East coast	9	45	6	8
Topaze Harbor, British Columbia.	3	0	16	11½
Torbay, England	6	0	13½	10
Toro Point, Chile	9	45		
Torta Bay, Africa, West coast	3	30	3	
Tortola, Virgin Islands	8	30	1½	
Touron Bay, Cochin China	3	0	4	
Tova, or Na Vatu Reef, South Pacific.	6	8	4	
Towan Island, China, East coast	9	20	13	
Townshend Harbor, Tierra del Fuego	2	30	5	
Tracadie, Prince Edward Island	7	0	3½	2
Tracey Harbor, British Columbia	Noon		16	11½
Tracy Island, Korea, South coast	8	58	11½	8½
Træ Islands, Norway	11	45	7	
Trawbreaga, Lough, Ireland	6	10	11½	8½
Tréguier, France	5	32	25	18½
Trek Island, White Sea	10	48	20	
Trepassey, Newfoundland	7	0	6½	5
Tréport, France	11	9	27	21
Tres Cruces, Point, Patagonia, West coast	1	15	16	
Triangles, Gulf of Mexico	.	.	1½	
Trieste, Adriatic	9	35	3½	
Trincomalie Harbor, Ceylon, South coast	8	18	2	1½
Tringano River, Gulf of Siam, China Sea, West coast.	8	0		
Trinidad, (Port Spain,) Caribbee Islands.	4	30	4	3
Trinity Bay, (Bull Island,) Newfoundland	7	22	3½	2
Trinity Harbor, Newfoundland	7	10	3½	2
Trinity Opening, Great Barrier Reefs	9	15	7–12	
Tripoli, (Syria,) Mediterranean	10	20	2	
Tristan da Cunha, South Atlantic	.	.	8	
Triton Bay, New Guinea	1	8	7	1
Triton Harbor, Newfoundland.	7	0?	2–4?	
Triton Bank, Magellan Strait	9	0	15	
Tromsö, Norway	1	45	8	
Troon, Scotland	11	50	10	7½
Troubridge Shoals, Australia, South coast	4	18	7	4–6
Truro, (Quay,) England	5	5	10	6
Tsang-chow Island, (Bias Bay,) China, East coast.	8	30		
Tsau-liang-hai or Chosan Harbor, Korea	7	45	7	5
Tsu-sima Sound, Korea.	8	30	8	6
Tsugar Strait, Japan.	5	0	5	
Tsuruga, Japan	1	30	2	
Tudri River, (Bar,) Hindoostan, West coast.	10	0	6½	5½
Tudwall, St., Road, Wales	7	45	14	
Tuesday Bay	1	0	6	
Tumaco Road, Ecuador	2	33	12	
Tunis, Mediterranean	.	.	3	
Turks Islands, Bahamas	.	.	3	
Turna Bay, White Sea	9	54	11	
Turner, Cape, Prince Edward Island	6	10	4	2
Turtle Island, (North,) Australia, West coast	11	0	18	
Turtle Island, South Pacific	6	11	4	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise.	
			Springs.	Neaps
	h.	m.	Feet.	Feet
Tuticorin Harbor, Gulf of Manar, Bay of Bengal, West coast.	1	15	2½	1¾
Tutukaka Harbor, New Zealand	7	0	9	7
Tweed River, (Danger Point,) Australia, East coast.	9	30	6	4½
Twofold Bay, Australia, East coast	8	15	5–7	5
Tylatiap Harbor, Java, South coast	8	45	3½	
Tynemouth, (Bar,) England	3	20	14¾	11¼
Tyssen Island, Falkland Islands	8	0	6	
Tytando Inlet, Java	6	30	5	3¼
Typa Anchorage, China, East coast	10	0	7	
Ubatuba, Brazil	4	0	4½	
Ubian Island, Sulu Sea	6	15	5	
Uinne, New Caledonia	6	48	4	
Uist, North, (Kallin,) Scotland, West coast	5	59	13½	9¼
Uist, North, (Vallay,) Scotland, West coast	6	10	11½	8¼
Uist, South, (Loch Boisdale,) Scotland, West c'st	5	47	12¾	9¼
Ulladulla Harbor, Australia, East coast	8	30	6	
Ullapool, Loch Broom, Scotland	6	40	14½	10¼
Ummen Nakheīlah, Persian Gulf	7	30?	8?	
Underwood, Port, New Zealand	6	10	8	6
Ungava, Hudson Bay	.	.	67	
Union Bay, La Plata	3	10	12	9
Union, Port la, Gulf of Fonseca, Central America	3	15	10¾	8¼
Unsang, Borneo	8	0	3½	
Upernavik, Greenland	11	0	8	
Upstart Bay, Australia, East coast	9	0	6	
Uraga, Japan	5	55	4½	½–1
Urakami, Japan	7	30	6	4
Urie Firth, Shetlands	9	45	6½	5
Ursula Island, Palawan, China Sea, East coast	11	0	7½	
Usborne, Port, Australia, West coast	1	45	34	
Ushant, France	3	32	19½	13¾
Ushruffi Islands, Red Sea	6	14	2–6	
Utria, New Granada	4	0	12	
Værö, Norway	Noon		9	7½
Valdivia, Port, Chile	10	35	5	
Valentia Harbor, Ireland	3	42	11	8
Valery, St., en-Caux, France	10	46	27	21½
Valery, St., sur-Somme, France	11	46	27	21½
Vallay, North Uist, Scotland, West coast	6	10	11½	8½
Vallenar River, Patagonia, West coast	0	18	5	
Valparaiso, Chile	9	32	5	
Vanderlin Island, Australia, North coast	9	30	7	4
Vansittart Bay, Australia, Northwest coast	9	15	6	
Vansittart's Saddle, Yellow Sea	4	20	10	8½
Vao, Port. (See Alcmène, New Caledonia)	8	6	4	
Vatoa or Turtle Island, South Pacific	6	11	4	
Vavau, South Pacific	6	20	5	
Veere-gat, Netherlands	1	0	15	11
Ventry, Ireland	3	44	10½	7¾
Venus Bay, Australia, South coast	11	56	7	
Venus Harbor, Australia, South coast	2	15	6	
Vera Cruz, Gulf of Mexico	.	.	2	
Vernon Channel, (Chusan Arch.,) China, East c'st.	9	40	14	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Versovah, Hindoostan, West coast	Noon	16	13
Verte Bay, Nova Scotia	10 0	9	5
Victoria, Port, Brazil	3 0	4	
Victoria, Port, Australia, South coast	2 40	5	
Victoria Strait, Juan de Fuca Strait	Irregular	7–10	5–8
Victoria River, Holdfast Reach, Australia, North-west coast.	9 0	16	10
Victoria River,(Mosquito Flat,) Australia, North-west coast.	0 19	15–24	
Victoria River,(Sandy Island,) Australia, North-west coast.	1 17	3–10	
Victoria River,(Turtle Point,) Australia, North-west coast.	7 15	7–13	
Victory Pass, Smyth Channel, South America, West coast.	1 25	6	
Vigo, Spain	3 0	12–13	
Vila Harbor, Sandwich Islands, New Hebrides	5 0	5	
Vin Harbor, Gulf of St. Lawrence	5 45	5	3
Vincent, St.. Cape, Madagascar, West coast	4 45	12	
Vincent, St., Caribbean Sea	3 0	1½	1
Vincent, St., Port, New Caledonia	5 50	4½	
Vingorla, Hindoostan, West coast	11 0	8	6½
Virgin, Cape, Magellan Strait	8 30	36–42	
Viti Levu, Fiji Islands	6 47	5¾	
Vivero, Spain, North coast	3 0	15	
Viziadroog. (See Geriah.)			
Vladimir, St., Bay, Gulf of Tartary	Irregular	2	
Volcano Islands, China, East coast	11 30	15	7½
Voronov, Cape, White Sea	11 20	17	
Vulavu, Isabel Island, Solomon Islands	about 4	4–5	
Waagoe Fiord, Faroe Islands	6 0	9½	7½
Waddington Harbor, Bute Inlet, British Columbia.	6 0	13	
Wahaay Harbor, (Ceram,) Moluccas, North c'st	6 0	3–4	
Waikato River, New Zealand	9 30	12	9
Waikawa Harbor, New Zealand	2 30	9	7
Wairoa River, New Zealand	6 45	7	4
Wakaya Island, Fiji Islands	6 0	4	3
Wakefield, Port, Australia, South coast	4 40	11	
Walker Creek, Choiseul Island, Falkland Isl'ds	6 20	5½	
Walker, River Tyne, England	. .	10½	
Wallace Harbor, Nova Scotia	10 30	8	5
Wallis Island, Torres Strait	Irregular	7	
Walton Bay, England	7 3	39¾	22½
Walvisch Bay, Africa, West coast	1 54	6	
Wanchu River, (entrance,) China, East coast	9 0	15½	
Wanchu River, (City,) China, East coast	9 30	15½	
Wang-kia Bay, Yellow Sea	2 30	9	7
Wang-kia-tia Bay, Yellow Sea	6 0	12	9
Wanganui River, New Zealand	10 15	8	6
Wanganui Inlet, New Zealand	11 20	7	6
Wangari Harbor, New Zealand	7 0	9	7
Wangaroa Harbor, New Zealand	8 15	7	
Wangaruru Harbor, New Zealand	7 10	9	7
Wangerocg, Germany	11 35	10	
Wapitagun Harbor, Gulf of St. Lawrence	10 30	5	3

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise. Springs.	Rise. Neaps.
	h. m.	Feet.	Feet.
Waratah Bay, Australia, South coast	Noon	8	
Waree River, Hindoostan, West coast	9 40	8	
Warleigh Quay, (River Tavy,) England	5 47	14¼	10¾
Warnboro' Sound, Australia, West coast	. .	3–4	
Warrenpoint, (Carlingford,) Ireland	11 10	14½	12
Warrenpoint, (Lough Foyle,) Ireland	6 20	6¼	5
Warsheek Roads, Africa, East coast	4 30	8	
Waterford, (Bridge,) Ireland	6 6	13½	10¾
Waterford, (Duncannon Fort,) Ireland	5 20	12½	10
Waterloo Bay, Africa, South coast	4 0	6	
Webeck	6 21	7	4
Webling Point, Spencer Gulf, Australia, South coast.	6 10	6–9	
Week Islands, Tierra del Fuego	2 0	5	
Wei-hai or Kyau-chau Bay, Yellow Sea	5 0	12	9
Wei-hai-wei Harbor, Yellow Sea	9 30	9	
Weir Head, River Tamar, England	6 17	5½	1¾
Welcome Bay, Patagonia, West coast	0 50	7½	
Wellesley Islands, Australia, North coast	7 30	8–12	
Wells, England	7 0	12	
Wells Bar, England	6 20	18	
Wenman Isles, Galapagos Islands	2 10		
Weser, (entrance,) Germany	11 30	14	
Weser, (light-vessel,) Germany	0 20	10	
West Cove, Kenmare River, Ireland	3 52	10	7½
West Gat, Netherlands	1 45	7	
West Hill, Australia, East coast	10 20	24	
West-kappelle, North Sea	0 40	14¾	11
West Quoddy, Bay of Fundy	11 12	21	17
West River, China, East coast. (See Si Kiang.)			
Western Port, (Muscle Rock,) Australia	0 12	8½	6½
Western Port, (Bourchier Channel,) Australia	1 13	10¾	8¾
Western Port, (French Island Spit,) Australia	1 0	10	8
Westmanshaven, Faroe Islands	8 0	9½	7½
Westness, Orkneys	9 11	10	7½
Weston-super-mare, England	6 54	37	28½
Westport, Ireland	4 57	12¾	9½
Wexford, Ireland	7 21	5	3½
Whaingaroa Harbor, New Zealand	9 50	12	
Whampoa, (Docks,) China, In March	1 40	7–8	
Whampoa, (Docks,) China, In April	1 15	7–8	
Whampoa, (Docks,) China, In May and June	0 30	7–8	
Whitby, England	3 45	15	11½
White Dog Islands, China, East coast	9 0	18	
Whitehaven, England	11 14	23½	18½
Whitehaven, Nova Scotia	8 0	6½	4½
Wick, Scotland	11 22	10	7½
Wicklow, Ireland	10 29	9	6½
Wide Bay, Australia, East coast	8 30	6	
Widewall, Orkneys	9 3	10	7½
Wigton, Scotland	11 30		
Wilberforce, Cape, Australia, North coast	8 10	10	
Wild Wave Bay, Loo Choo Islands	8 0	8	
William, Port, Falkland Islands	5 15	7	5½
William, Port, New Zealand	0 45	8	6
William, Port, Scotland, West coast	11 10	18	10
Willemstad, North Sea	3 30	10	

Digitized by Google

TABLE LVI.

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.	Rise.	
		Springs.	Neaps.
	h. m.	Feet.	Feet.
Willis Islets, Australia, East coast	8 0	6	
Willoughby, Cape, Kangaroo Island, Australia	4 10	6	
Willunga, Port, Australia, South coast	4 0	6	
Winter Harbor, Melville Island	1 30	3¾	
Winterton Ness, England	8 25	7¾	6¼
Wisbeach, England	7 30	15	
Wisbeach Eye, England	. .	20	
Wivenhoe, Colne River, England	0 10	15	10
Wolstenholm Sound, Arctic Regions	11 8	7½	
Woodbridge or Bawdsey Haven, (Bar,) England	11 45	12	9
Woodbridge, (Kingston Quay,) England	0 35	10	
Woodbridge, (Wilford Bridge,) England	0 55	7	
Woodlark Island, Louisiade Archipelago	7 15	4	
Wood's Bay, Strait of Magellan	0 34	8	
Woody Island, Great Sandy Strait, Australia, East coast.	9 14	10	7
Woolwich, England	1 37	18¼	15¼
Workington, England	11 4	20	15
Wotje or Romanzoff Islands, Marshall Islands	2 30	7	
Wrabness, Stour River, England	0 29	12	
Wranger Oog, Germany	Noon	9?	
Wrath, Cape, Scotland	7 30	15¼	
Wreck Bay, Loyalty Islands	6 30	5–6	
Wreck Reef, (Bird Islet,) Australia, East coast	8 3	6	
Wuchu, Si Kiang, China, East coast	. .	1–1½	
Wusung River, (entrance,) Yang-tse-Kiang, China, East coast.	0 30	15	10¼
Wusung River, (Fort A.,) China, East coast.	0 30	15	10¼
Wusung River, (Pheasant Point,) China, East coast.	0 35	13	8
Wyk, Fohr Island, Denmark	1 50	8	
Wynkoop's Bay, Java	5 0	4¼	4
		1½	
Yafa, Mediterranean	10 0	8¼	3
Yama Gawa Harbor, Japan	7 15	6	
Yang-ho, Yellow Sea	0 15	15	10
Yang-tse-Kiang, (light-ship at entrance,) China, East coast.	Noon		
Yamada Harbor, Japan	4 30	4	
Yarmouth Haven, (Brush,) England	. .	5¾	4¼
Yarmouth, Bay of Fundy	10 9	16	13
Yarmouth Bridge, England	. .	5	4
Yarmouth Road, England	9 15	6	4¼
Yarmouth, Isle of Wight, England	10 0 and noon	7	6¼
Yealm River, Bigbury Bay, England	5 37	16¼	11¼
Yedo Bay, (Yokohama,) Japan	6 0	6¼	4¾
Yellaboi, Africa, West coast	7 10	10	
Yeu, Ile d', France	3 6	14¼	10
Ylo Road, Peru	8 15	6	
Yobuko, Japan	9 16	9	6¼
Yokohama, Yedo Bay, Japan	6 0	6¼	4¼
York, Cape, Australia, East coast	11 15	10	7
York Factory, Hudson Bay	11 15	10–14	
York Road, Magellan Strait	2 0	9	
York Harbor, Newfoundland	10 37	5¼?	
Youghal, Ireland	5 14	12¾	10

Digitized by Google

TIME OF HIGH WATER ON FULL AND CHANGE DAYS, &c.—Continued.

Place.	High Water, Full and Change.		Rise. Springs.	Rise. Neaps.
	h.	m.	Feet.	Feet.
Yugi Sima, Japan	11	25	11½	6¾
Yu-lin-kan Bay, China Sea	9	5	2¼	
Yung River, Chinhae, China, East coast	11	20	12½	
Yung River, Ning-po-fu, China, East coast	1	0	9	
Yung-hing Bay, Korea	5	20	2½	
Yura Harbor, Japan	6	5	6½	
Yuranouchi, Japan	6	0	5½	4½
Zambezi River, (Pearl Island,) Africa, East coast	4	30	12–15	
Zand Bay, Java	5	0	4¾	
Zanzibar, Africa, East coast	4	20	11	8½
Zanzibar, (Channel,) Africa, East coast	4	15	11	
Zaudzi, Mayotta, Comoro Islands	4	10	12	
Zebú, Port, Filipinas	Noon		7	
Zeyla, Africa, East coast	7	15	8½	
Zierikzee, Netherlands	2	0	10½	9
Zoolla, Red Sea	.	.	4–5	3

Digitized by Google

TABLE LVII.

The following table contains extracts from the Nautical Almanac for the year 1836, in those parts which are used in this work, to accommodate those who may not have a copy of that Almanac to refer to.

Lunar Distances and Proportional Logarithms.

Day of the Month. Mean Time.	STARS.	0 Hours. Distances.	0 Hours. P. L.	3 Hours. Distances.	3 Hours. P. L.	6 Hours. Distances.	6 Hours. P. L.	9 Hours. Distances.	9 Hours. P. L.
1836.		° ′ ″		° ″		° ′ ″		° ′ ″	
January 6	Aldebaran W.	66 8 59	2880	67 41 43	2872	69 14 38	2864	70 47 43	2856
April 1	Antares ..E.	61 40 13	2348	59 55 24	2337	58 10 19	2326	56 24 58	2317
May 11	Sun......E.	46 34 2	3097	45 5 49	3108	43 37 49	3117	42 10 00	3127
June 20	Venus....W.	30 58 49	3035	32 28 16	3019	33 58 7	3002	35 28 17	2985
Oct. 30	Sun......E.	112 54 10	3458	111 32 59	3459	110 11 49	3460	108 50 40	3460

Day of the Month. Mean Time.	STARS.	12 Hours. Distances.	12 Hours. P. L.	15 Hours. Distances	15 Hours. P. L.	18 Hours. Distances.	18 Hours. P. L.	21 Hours. Distances.	21 Hours. P. L.
1836.		° ′ ″		° ′ ″		° ′ ″		° ′	
Feb. 12	Sun......E.	51 28 10	2552	49 48 9	2551	48 8 7	2551	46 28 4	2551
Aug 26	Mars.....E.	114 55 6	2455	113 12 49	2467	111 30 49	2479	109 49 7	2492

Moon's Semi-diameter, Horizontal Parallax, &c.

Day of the Month. Mean Time.	Sun's Longitude. Noon.	Sun's Latitude. Noon.	Log. Radius Vector. Noon.	Moon's Semi-diameter. Noon.	Moon's Semi-diameter. Midn.	Moon's Horizontal Parallax. Noon.	Moon's Horizontal Parallax. Midn.	
	° ′ ″	″		′	′ ″	′ ″	′ ″	Examples I. IX. X.
January 6	285 16 27.6	N. 0.43	9.9926712	15 4.8	15 8.5	55 20.3	55 33.8	p. 232, 241, 242.
April 1	11 47 34.6	0.66	0.0000753	15 58.7	16 3.5	58 38.1	58 55.9	Ex. II. p. 233.
Oct. 30	217 7 36.5	0.34	9.9965769	14 45.6	14 45.7	54 10.1	54 10.3	III. VIII. 234, 240.
May 11	50 45 58.8	S. 0.10	0.0046545	15 16.8	15 12.5	56 4.4	55 48.6	Ex. IV. p. 235.
Feb. 12	322 51 54.9	0.23	9.9945669	16 16.2	16 17.2	59 42.5	59 46.0	Ex. V. p. 236.
13	323 52 33.0	0.33	9.9946561	16 17.6	16 17.3	59 47.4	59 46.3	
June 20	89 5 53.8	N. 0.86	0.0070882	15 9.6	15 15.2	55 38.1	55 58.6	Ex. VI. p 237.
Aug. 26	153 12 57.6	S. 0.48	0.0042613	16 14.5	16 10.0	59 36.3	59 19.5	Ex. VII. p. 238.
27	154 10 55.6	0.44	0.0041614	16 4.7	15 58.9	59 0.3	58 39.0	
June 26	94 49 8.9	N. 0.17	0.0071787	16 30.9	16 35.7	60 36.4	60 53.8	Ex. I. p. 172.
27	95 46 20.0	0.05	0.0071880	16 39.4	16 41.8	61 7.4	61 16.4	
Sept. 26	183 24 26.6	S. 0.32	0.0007178	15 32.4	15 26.9	57 1.7	56 41.4	Ex. II. p. 172.
Nov. 29	247 22 11.8	N. 0.32	9.9937878	14 48.5	14 51.4	54 20.6	54 31.1	Ex. p. 214.

Sun's Right Ascension, &c.

Day of the Month. Mean Time.	THE SUN'S Right Ascension.	THE SUN'S Declination.	THE SUN'S Semi-diam.	Equation of Time, *to be applied* * *to Mean Time.*	Sideral Time.	
	h. m. s.	° ′ ″	′ ″	m. s.	h. m. s.	
Nov. 29	16 22 14.56	S. 21 33 39.7	16 14.8	+11 21.56	16 33 36 12	Example, p. 213
30	16 26 32.98	21 43 28.7	16 14.9	+10 59.70	16 37 32.68	
May 26	4 13 2.51	N. 21 11 14.0	15 48.0	+ 3 17.61	4 16 20.12	Ex. I. p. 215.
27	4 17 5.56	21 21 21.2	15 47.8	+ 3 11.12	4 20 16.68	
Jan. 5	19 1 55.40	S. 22 41 53.8	16 17.3	— 5 26.11	18 56 29.29	Ex. II. p. 216.
6	19 6 18.78	22 35 10.5	16 17.3	— 5 52.93	19 0 25.85	
Sept. 8	11 7 47.32	N. 5 35 55.7	15 54.5	+ 2 31.30	11 10 18.62	Ex. I. p. 217.
9	11 11 23.47	5 13 14.6	15 54.8	+ 2 51.70	11 14 15.17	
April 16	1 38 20.06	10 14 7.4	15 56.6	+ 0 17.81	1 38 37.87	Ex. II. p. 218.
17	1 42 2.38	10 35 16.0	15 56.4	+ 0 32.05	1 42 34.43	
July 24	8 15 5.79	19 50 18.5	15 46.2	— 6 8.74	8 8 57.05	Ex. V. p. 223.
25	8 19 3.18	19 37 27.4	15 46.3	— 6 9.57	8 12 53.61	
March 10	23 23 10.85	S. 3 58 17.9	16 6.7	—10 25.45	23 12 45.40	Ex. VI. p. 224.
11	23 26 51.37	3 34 45.2	16 6.5	—10 9.41	23 16 41.96	
Oct. 30	14 19 6.64	13 54 18.2	16 8.5	+16 12.78	14 35 19.42	III. 234 VIII. 240.
May 11	3 13 18.24	N. 17 57 44.4	15 50.7	+ 3 53.53	3 17 11.77	Ex. IV. p. 235.
Feb. 12	21 40 51.50	S. 13 54 27.3	16 13.0	+14 33.06	21 26 18.14	Ex. V. p. 236.

* Those with the sign + are to be added to the mean time; those with the sign — are to be subtracted, to obtain the apparent time. These signs must be changed if we wish to obtain the mean time from the apparent time.

Digitized by Google

TABLE LVII.

The following table contains extracts from the Nautical Almanac for the year 1836, in those parts which are used in this work, to accommodate those who may not have a copy of that Almanac to refer to.

Sun's Declination, &c.

Day of the Month.	THE SUN'S				Sid. Time of the S. Diam. passing the meridian.	Equation of Time, to be applied to the Apparent Time.	Diff. for 1 hour	
App. Time.	Right Ascension.	Diff. for 1 hour.	Declination.	Diff. for 1 hour.				
1836.	h. m. s.	s.	° ′ ″	″	m. s.	m. s.	′	
May 9	3 5 29.31	9.744	N. 17 26 27.2	39.43	1 6.64	— 3 48.73	0.112	} Ex. p. 220.
10	3 9 23.16	9.769	17 42 13.4	38.69	1 5.72	— 3 51.42	0.088	
March 25	0 17 56.79	9.081	1 56 41.3	58.82	1 4.39	+ 6 2.10	0.774	Ex. V. p. 157.
July 25	8 19 4.19	9.866	19 37 24.1	32.95	1 7.16	+ 6 9.57	0.009	} Ex. I. p. 247.
26	8 23 0.98	9.841	19 24 13.3	33.75	1 7.08	+ 6 9.79	0.015	
Nov. 25	16 5 5.68	10.650	S. 20 50 14.8	28.58	1 9.68	—12 42.11	0.791	} Ex. II. p. 247.
26	16 9 21.29	10.681	21 1 40.7	27.59	1 9.78	—12 23.12	0.823	
April 11	1 19 53.95	9.189	N. 8 26 0.9	54.[illegible]0	1 4.74	+ 0 58.69	0.665	Ex. p. 250.
28	2 23 15.16	9.484	14 15 1.3	46.6[illegible]	1 5 77	— 2 40.94	0.371	Ex. p. 248.

Moon's Declination, &c.

Day of the Month.	Hour.	THE MOON'S			
Mean Time.		Right Ascension.	Declination.	Diff. declination for 10 minutes.	
1836.	h.	h. m. s.	° ′ ″	″	
April 18	7	3 52 47.56	N. 21 13 51.7	88.80	Ex. p. 171
June 26	15	16 29 28.69	S. 23 37 43.2	87.98	} Ex. I. p. 172.
	16	16 32 8.61	23 46 31.1	86.33	
Sept. 26	7	1 38 36.16	N. 8 47 27.3	144.82	} Ex. II. p. 172.
	8	1 40 35.44	9 1 56.2	144.27	
Nov 29	2	9 24 38.95	20 41 6.1	96.00	Ex. III. p. 173.
	3	9 26 39.34	20 31 30.1	96.90	Ex. p. 213.
April 28	12	12 32 52.81	0 20 50.8	159.38	} Ex. p. 248.
	13	12 34 57.22	0 4 54.5	159.58	

Moon's Passage over the Meridian, &c.

Day of the Month.	Moon's Longitude.		Moon's Latitude.		Age.	Meridian Passage.	
Mean Time.	*Noon.*	*Midnight.*	*Noon.*	*Midnight.*	*Noon*		
1836.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	d.	h. m.	
April 18	57 4 35.8	63 3 59.5	N. 0 38 36.9	N. 1 11 9.5	2.5	1 55.6	} Ex. p. 170.
19	69 1 30.0	74 57 30.9	1 42 46.2	2 13 9.0	3.5	2 43.0	
June 26	240 1 41.7	247 28 26.0	S. 0 58 3.9	S. 1 37 0.0	12.3	9 55.9	} Ex. I. p. 172.
27	254 59 41.8	262 34 28.9	2 14 35.9	2 50 4.6	13.3	10 59.8	
Sept. 25	8 50 46.8	15 34 19.6	2 47 10.5	2 15 23.7	14.5	12 42.8	} Ex. II. p. 172.
26	22 12 43.5	28 45 53.9	1 42 7.3	1 7 52.9	15.5	13 28.0	
Nov. 28	124 8 16.4	130 4 34.6	N. 5 11 16.5	N. 5 13 15.9	19.4	16 33.1	} Ex. III. p. 173.
29	136 2 4.2	142 1 16.1	5 11 53.0	5 7 6.6	20.4	17 18.6	
March 17	358 27 2.5	5 1 33.1	S. 4 3 54.9	S. 3 41 14.0	0.1	0 21.1	Ex. I. p. 121.
May 23	149 27 19.5	155 45 12.4	N. 5 12 19.7	N. 5 4 46.3	7.9	6 21.1	Ex. II. p. 121.

Declinations, Right Ascensions, and Time of passing the Meridian of Jupiter, Venus, &c.

Day of the Month.	GEOCENTRIC			Meridian Passage.	HELIOCENTRIC			
	Right Ascension.	Declination.	Log. of dist. from the Earth.		Longitude.	Latitude.	Log. of Rad. Vect.	
Mean T.	*Noon.*	*Noon.*	*Noon.*		*Noon.*	*Noon.*	*Noon.*	
1836.	h. m. s.	° ′ ″		h. m.	° ′ ″	° ′ ″		
Oct. 22	9 11 53.47	N. 16 47 17.2	0.7390451	19 5.4	124 56 35.6	N. 0 34 45.9	0.7236939	} Example I. p. 174.
23	9 12 22.92	16 45 18.1	0.7378516	19 2.0	125 1 24.2	0 34 51.9	0.7237216	Jupiter.
Sept. 16	8 41 55.60	14 49 33.7	9.7458961	20 59.5	26 19 7.0	S. 2 33 25.3	9.8599886	} Example II. p. 175.
17	8 45 14.25	14 44 22.1	9.7516468	20 58.9	27 54 59.6	2 29 38.0	9.8599080	Venus.
May 26	7 8 6.55	22 49 18.4	0.7760038	2 51.4	112 52 34.8	N. 0 19 13.6	0.7193880	} Example I. p. 215.
27	7 8 57.01	22 48 0.0	0.7767647	2 48.3	112 57 29.1	0 19 20.2	0.7194179	Jupiter.
Jan. 5	14 10 11.19	S. 10 35 28.6	1.0021683	19 10.8	208 31 44.1	2 28 28.7	0.9895685	} Example II. p. 216.
6	14 10 26.19	10 36 33.3	1.0014895	19 7.1	208 33 39.2	2 28 28.2	0.9895807	Saturn.
April 28	6 46 47.41	N. 23 16 40.1	0.7495943	4 20.3	110 34 53.1	0 16 9.3	0.7185465	} Example, p. 249.
29	6 47 27.73	23 15 58.8	0.7506968	4 17.0	110 39 48.6	0 16 15.9	0.7185767	Jupiter.

Digitized by Google

TABLE LVIII.

Sun's Altitude.	Polar Distance.	Latitude. 0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	Polar Distance.	Sun's Altitude.
°	°	′	′	′	′		′	′	′	′	′	′	′	′	′	′	′	°	°
10	110	.4	.4	.4	.5	.5	.6	.7	.8	1.0	1.3	1.8	2.9					110	10
20		.4	.4	.5	.6	.7	.8	1.0	1.2	1.6	2.6								20
30		.4	.5	.6	.7	.9	1.1	1.5	2.3										30
40		.5	.6	.8	1.0	1.3													40
50		.7	.9	1.2															50
60		.9																	60
10	105	.3	.3	.3	.3	.4	.4	.5	.6	.8	.9	1.2	1.8	3.0				105	10
20		.3	.3	.4	.4	.5	.6	.7	.9	1.2	1.6	2.7							20
30		.3	.4	.5	.6	.7	.8	1.1	1.5	2.4									30
40		.4	.5	.6	.7	1.0	1.3												40
50		.4	.6	.8	1.2														50
60		.6	.9																60
15	100	.2	.2	.2	.3	.3	.4	.4	.5	.6	.8	1.1	1.6	2.9				100	15
20		.2	.2	.3	.3	.4	.5	.5	.7	.9	1.1	1.6	2.7						20
30		.2	.3	.3	.4	.5	.6	.8	1.1	1.3	2.4								30
40		.2	.3	.4	.6	.7	.9	1.3	2.1										40
50		.3	.4	.6	.8	1.2													50
60		.3	.6	.9															60
15	95	.1	.1	.1	.2	.2	.3	.3	.4	.5	.6	.8	1.1	1.7	3.0			95	15
20		.1	.1	.2	.2	.3	.3	.4	.5	.6	.8	1.1	1.6	2.8					20
30		.1	.2	.2	.3	.4	.5	.6	.8	1.0	1.5	2.5							30
40		.1	.2	.3	.4	.5	.7	.9	1.3	2.1									40
50		.1	.3	.4	.6	.8	1.1												50
60		.2	.3	.6	.9														60
20	90	.0	.0	.1	.1	.1	.2	.2	.3	.4	.6	.7	1.1	1.6	3.0			90	20
30		.0	.1	.1	.2	.2	.3	.4	.5	.7	1.0	1.5	2.7						30
40		.0	.1	.2	.3	.3	.5	.6	.9	1.3	2.2								40
50		.0	.1	.2	.4	.5	.8	1.1											50
60		.0	.2	.3	.5	.9													60
70		.0	.2	.6	1.1														70
20	85	.1*	.1*	.0	.0	.0	.1	.1	.2	.3	.3	.5	.7	1.0	1.6	3.1		85	20
30		.1*	.0	.0	.1	.1	.2	.2	.4	.5	.7	1.0	1.5	2.7					30
40		.1*	.0	.0	.1	.2	.3	.4	.6	.9	1.3	2.3							40
50		.1*	.0	.1	.2	.3	.5	.7	1.1										50
60		.2*	.0	.1	.3	.5	.9												60
70		.3*	.0	.2	.6	1.1													70
20	80	.2*	.2*	.1*	.1*	.1*	.0	.0	.0	.1	.1	.2	.4	.5	.9	1.5	3.1	80	20
30		.2*	.2*	.1*	.0	.0	.1	.1	.2	.3	.4	.6	.9	1.5	2.8				30
40		.2*	.2*	.1*	.0	.1	.2	.3	.4	.6	.9	1.3	2.4						40
50		.3*	.2*	.1*	.1	.2	.3	.5	.7	1.1									50
60		.4*	.2*	.0	.1	.3	.5	.9											60
70		.6*	.3*	.0	.2	.6	1.2												70
20	75	.3*	.3*	.2*	.2*	.2*	.1*	.1*	.1*	.1*	.0	.0	1	.2	.3	.6	1.2	75	20
30		.3*	.3*	.2*	.2*	.1*	.1*	.0	.1	.1	.2	.4	.6	.9	1.5	3.0			30
40		.4*	.3*	.2*	.1*	.1*	.0	.1	.2	.4	.5	.8	1.3	2.5					40
50		.4*	.3*	.2*	.1*	.0	.1	.3	.5	.7	1.1								50
60		.6*	.4*	.2*	.1*	.1	.3	.5	.9										60
70		1.2*	.6*	.3*	.0	.2	.6	1.2											70
20	70	.4*	.4*	.3*	.3*	.3*	.3*	.2*	.2*	.2*	.2*	.2*	.2*	.2*	.2*	.2*	.2*	70	20
30		.4*	.4*	.3*	.3*	.2*	.2*	.1*	.1*	.0	.0	.1	.2	.6	.8	1.5	3.1		30
40		.5*	.4*	.3*	.3*	.2*	.1*	.0	.1	.2	.3	.5	.8	1.3	2.6				40
50		.6*	.5*	.3*	.2*	.2*	.0	.1	.3	.4	.7	1.1							50
60		.9*	.6*	.4*	.3*	.1*	.1	.2	.5	.9									60
70			1.2*	.6*	.3*	.1*	.2	.6	1.2										70
Sun's Altitude.	Polar Distance.	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	Polar Distance.	Sun's Altitude.
		Latitude.																	

Digitized by Google

TABLE LVIII.

Table LVIII shows nearly the error in longitude, in miles and tenths of a mile, occasioned by an error of one mile in the latitude.

Thus, when the sun's altitude is 30°, the latitude 30°, and the polar distance 100°, the error is 8 tenths of a mile.

The error affects the longitude as follows:—

When in *west* long., and the time is found in column	A. M.	the long. is	decreased;	when the correction is marked *, the longitude is	increased.
	P. M.		increased;		decreased.
When in *east* long., and the time is found in column	A. M.	the long. is	increased;	when the correction is marked *, the longitude is	decreased.
	P. M.		decreased;		increased.

Digitized by Google

CATALOGUE OF THE TABLES,

WITH

EXAMPLES OF THE USES OF THOSE WHICH ARE NOT EXPLAINED IN OTHER PARTS OF THIS WORK

TABLES I. and II. *Difference of Latitude and Departure.*—The first table contains the difference of latitude and departure corresponding to distances not exceeding 300, and for courses to every quarter-point of the compass. Table II. is of the same nature and extent, but for courses consisting of whole degrees. The manner of using these tables is particularly explained under the article of Inspection, in the different Problems of Plane, Middle Latitude, and Mercator's Sailing.

TABLE III. *Meridional Parts.*—An explanation of this table may be found in pages 78 and 79, and the uses of it are shown in all the Problems of Mercator's Sailing.

TABLE IV. *The Sun's Declination.*—This table is explained in page 156.

TABLE IV. A. This table contains the *equation of time* for every noon at Greenwich, and is to be reduced to any other hour by means of Table VI. A. Thus, suppose the equation of time was required for May 2, 1836, sea account at 10 A. M. apparent time, corresponding to May 1d. 22h. by the N. A. Table IV. A. gives the equation May 1, at noon, *sub.* 3m. 6s. and daily *increase* 7s. Find this at the top in Table VI. A. and 22h. at the side, the corresponding correction 6s. *increases* the equation 3m. 6s. to 3m. 12s. which is the equation at the proposed time. This 6s. would have been *subtractive* if the equation had been *decreasing*, as it is in March. The equation of time being thus found, *sub.* 3m. 12s. is to be subtracted from the *apparent* time 22h. as in the table to get the *mean* time 21h 56m. 48s. If the *mean* time 21h. 56m. 48s. had been given to find the *apparent*, it must be applied differently from the direction in the table, and in this example must therefore be added to 21h. 56m. 48s. to obtain the apparent time 22h.

TABLE V. *For reducing the Sun's Declination given for Noon at Greenwich to any other Time under any other Meridian.*—The manner of using this and the preceding Table IV. is explained in pages 156 and 157.

TABLE VI. *The Sun's Right Ascension.*—The Sun's mean right ascension given in this table may be used when a Nautical Almanac cannot be procured, and no great accuracy is required. The table is to be entered at the top with the month, and at the side with the day of the month.

TABLE VI. A. is explained in the precepts for the use of Table IV. A.

TABLE VII. *Amplitudes.*—This table is explained in page 159.

TABLE VIII. *Right Ascensions and Declinations of the principal fixed Stars.*—This table contains the right ascensions and declinations of the principal fixed stars, adapted to the 1st of January, 1830, and the annual variations in right ascension and declination; by means of which the right ascensions and declinations of any of these stars may be obtained for any time before or after the year 1830, by the rule at the end of the table. To illustrate the method of doing this, we shall here give the following examples:—

To find the right ascension of a star at any time.

EXAMPLE I.

Required the right ascension of Aldebaran, January 1, 1834.

	h.	m.	s.
R. A by the Table in 1830	4	26	11
Variation in 4 years, add			14
R. A. in January, 1834	4	26	25

EXAMPLE II.

Required the right ascension of Aldebaran, January 1, 1810.

	h.	m.	s
R. A. by the Table in 1830	4	26	11
Variation in 20 years, subtract		1	9
R. A. on January 1, 1810	4	25	9

EXAMPLE III.

Required the right ascension of Spica, May 20, 1836.

	h.	m.	s.
R. A. by the Table in 1830	13	16	15
Variation in 6 years 4⅔ months, add			20
R. A. May 20, 1836	13	16	35

EXAMPLE IV.

Required the right ascension of Sirius, November 6, 1817.

	h.	m.	s.
R. A. by the Table in 1830	6	37	39
Variation in 13 years, subtract			34
R. A. in January, 1817	6	37	5
Variation for 10 months and 6 days, add			2
R. A. November 6, 1817	6	37	7

The sun's right ascension for any time may be found accurately by the Nautical Almanac, by taking proportional parts of the daily difference, as will be explained in the precepts of Table XXX. XXXI. But in cases where no great accuracy is required, the right ascension may be obtained within 2 or 3 minutes, by means of Table VI.

Digitized by Google

To find the declination of a star at any time.

EXAMPLE I.

Required the declination of Aldebaran, January 1, 1834.

Declination by the Table in 1830	16° 10′ N.
Variation in 4 years 32″, add nearly....	1
Declination in 1834	16° 11′ N.

EXAMPLE II.

Required the declination of Aldebaran, January 1, 1820.

Declination by the Table in 1830	16° 10′ N.
Variation in 10 years 1′ 20″, subtract ...	1
Declination January 1, 1810............	16° 9′ N.

EXAMPLE III.

Required the declination of the star Spica, May 20, 1836.

Declination by the Table in 1830........	10° 16′ S.
Variation in 6 years 4⅔ months.........	2
Declination May 20, 1836	10° 18′ S.

EXAMPLE IV.

Required the declination of Sirius, November 6, 1807.

Declination by the Table in 1830	16° 29′ S.
Var. in 22 years 1 month 24 days, is sub.	2
Declination November 6, 1807	16° 27′ S.

The right ascensions and declinations obtained by the preceding calculations, are the mean values, to which must be applied the corrections for the Nutation and Aberration Tables XLII. XLIII. in cases where great accuracy is required, as is now done in the Nautical Almanac for 100 of the brightest stars for every 10 days in the year; and the numbers in the Nautical Almanac are to be preferred. We must neglect the correction Part III., Table XLIII., **when the mean equinox is used, as is the case with the improved Nautical Almanac.**

To find when a star will be on the meridian.

Rule. Find the right ascension of the sun and star in the preceding Tables VI. and VIII.; subtract the sun's right ascension from the star's, having previously increased the latter by 24 hours when the sun's right ascension is the greatest; the remainder will be the time of the star's coming to the meridian. If the remainder be greater than 12 hours, the star will come to the meridian after midnight; but if less than 12 hours, before midnight.

EXAMPLE I.

At what time will Aldebaran be on the meridian, January 1?

	h. m.
Aldebaran's right ascension................	4 26
Add.......................................	24
	28 26
Sun's right ascension......................	18 46
Aldebaran souths in the evening...........	9 40

EXAMPLE II.

At what time will Pollux be on the meridian, March 31?

	h. m
Pollux's right ascension......................	7 35
Sun's right ascension........................	38
Comes to the meridian in the evening	6 57

EXAMPLE III.

At what time will the star Regulus be on the meridian, December 12?

	h. m.
Regulus's right ascension..................	9 59
Add.	24
	33 59
Sun's right ascension......................	17 17
After midnight............................	16 42
Subtract..................................	12
In the morning............................	4 42

EXAMPLE IV.

Required the time when the star Fomalhaut comes on the meridian, June 1.

	h. m.
Fomalhaut's right ascension.................	22 48
Sun's right ascension.......................	4 36
After midnight..............................	18 12
Subtract....................................	12
In the morning..............................	6 12

To find what star will come upon the meridian at any given time.

Rule. Add the time from noon* to the right ascension of the sun, the sum (rejecting 24 hours when it exceeds 24) will be the right ascension of the star required to be known; with which enter the table of the star's right ascension, and find what star's right ascension agrees with, or comes the nearest to it, and that will be the star required, if the declination of the star agrees with the table, which may be ascertained by observing the meridian altitude of the star, the latitude of the place being given.

EXAMPLE I.

What star will be on the meridian about 10 at night, January 26?

	h. m.
Sun's right ascension January 26...........	20 34
Given time 10 hours P. M....................	10
	30 34
Subtract....................................	24
Nearly answers to Sirius....................	6 34

EXAMPLE II.

What star will be upon the meridian 30 minutes past four in the morning, May 10?

	h. m.
Sun's right ascension May 10.	3 8
Given time 16 hours 30 minutes..............	16 30
Right ascension of mid. heaven............	19 38

Answers nearly to Altair in the Eagle.

* The time from noon must be reckoned *from* the preceding noon, so that 4h. A. M. must be called 16h

Digitized by Google

EXAMPLE III.

What star will be on the meridian at 6h. 53m. P. M April 1?

	h.	m.
Sun's right ascension April 1		42
Given time	6	53
Right ascension of the meridian	7	35

Answers nearly to Pollux.

EXAMPLE IV.

What star will be on the meridian, September 1, at 5h. 37m. P. M.?

	h.	m.
Sun's right ascension Sept. 1	10	41
Given time	5	37
Right ascension of the meridian	16	18

Answers nearly to Antares.

In all the preceding examples, the right ascension of the sun ought to have been calculated for the moment of the star's passing the meridian, as will be more fully explained in the precepts of Tables XXX. XXXI.

TABLE IX. *Semi-diurnal and Semi-nocturnal arches.*—This table exhibits half the time that a celestial object continues above the horizon when the latitude and declination are of the same name, or below when they are of a contrary name; the former time being usually called the semi-diurnal arch, the latter the semi-nocturnal arch; whence the time of rising and setting may be computed by the following rules:—

To find the time of the sun's rising and setting, and the length of the day and night.

RULE. Find the sun's declination at the top of the table, and the latitude in either side column; under the former, and opposite the latter, will be the time of the sun's setting if the latitude and declination are of the same name, but the time of rising if of different names. The time of rising, subtracted from 12 hours, will give the time of setting; or the time of setting, subtracted from 12 hours, will give the time of rising. The time of rising, being doubled, will give the length of the night; and the time of setting, being doubled, will give the length of the day.

EXAMPLE I.

Let it be required to find the time of the sun's rising and setting, with the length of the day and night, in latitude 51° north, the 19th of July, 1837.

The sun's declination on the given day is 20° 52′ north, or 21° nearly, under which, and against the latitude 51°, stand 7h. 53m., the time of the sun's setting on the given day, in lat. 51° north, which doubled, gives 15h. 46m., the length of the day; and by subtracting 7h 53m. from 12h., the remainder, 4h. 7m., is the time of the sun's rising, which doubled gives 8h. 14m. the length of the night.

But, when the sun has 21° south declination in this latitude, the time of sun-setting becomes 4h. 7m., the time of rising 7h. 53m., the length of the day 8h. 14m., and the length of the night 15h. 46m., as was the case nearly on the 26th of November, 1837.

EXAMPLE II.

Let it be required to find the time of the sun's rising, setting, and the length of the day and night, at Boston, the 12th of July, 1839.

	h	m
Under 22°, which is nearly the declination on that day, and against 42° 23′ or 42° N., the latitude of Boston, stands the time of the sun's setting	7	25
Subtracted from 12h. leaves sun-rising	4	35
Sun-setting doubled is the length of day	14	50
Sun-rising doubled is the length of night	9	10

EXAMPLE III.

Required the time of the sun's rising and setting, and length of day, in latitude 34° 29′ S., May 15th, 1836.

	h.	m.
Under the declination 18° 57′ or 19° N. and against the lat. 34° S. stands the	12	0
sun's rising	6	54
Time of sun's setting	5	6
		2
The length of the day	10	12
And 6h 54m. doubled is length of night	13	48

When a great degree of accuracy is required, proportional parts may be taken for the minutes of latitude and declination.

To find the time of rising and setting of stars whose declination does not exceed 23° 28′

Enter Table IX. and find the star's declination at the top, and the latitude at the side; under the former, and opposite to the latter, will be the semi-diurnal arch, when the latitude and declination are both north or both south; but if one be north and the other south, the difference between the Tabular number and 12 hours will be the semi-diurnal arch. Find the time of the star's coming to the meridian according to the precepts of Table VIII., and subtract therefrom the semi-diurnal arch; the difference will be the time of rising; or by adding together the semi-diurnal arch, and the time of passing the meridian, the time of setting will be obtained.

EXAMPLE IV.

Required when the star Arcturus rises and sets December 1, in latitude 51° N.

	h.	m.
The time of the star's coming to the meridian, or southing, in the morning, is nearly	9	39
Then under star's declination 20° nearly, and against latitude 51°, stand	7	47
Time of star's rising in the morning	1	52
Added gives the time of the star's setting	17	26
	12	
Star sets 26 minutes after 5 in the evening	5	26

EXAMPLE V.

What time will the Dog-star Sirius rise and set at Philadelphia, Feb. 1?

	h.	m
Under the declination, which is nearly 16° S., and against the latitude,	12	0
which is nearly 40° N., stand	6	56
Subtracted from 12h. leaves half the time the star is above the horizon	5	4
The star comes to the meridian in the evening nearly at	9	40
Sum, rejecting 12 hours, is the time of setting in the morning	2	44
Difference is the time of rising in the evening	4	36

Digitized by Google

In like manner may the rising and setting of any planet be found when the declination does not exceed 23° 28', and the time of the passage over the meridian is known.

Suppose it was required to find the time of Jupiter's rising and setting, August 7, 1836, civil account, in the latitude of 52° N.

In the Nautical Almanac for 1836, I find that Jupiter passes the meridian, August 6d. 23h. 11m., or August 7d. 11h. 11m. A. M., civil account, his declination being 20° 17' N., or nearly 20°. Under the declination 20°, and opposite to the latitude 52°, stand 7h. 51m., which is half the time Jupiter is above the horizon; this subtracted from 12h. leaves half the time that he is below the horizon, 4h. 9m.; subtracting 7h. 51m. from 11h. 11m. A. M. leaves 3h. 20m. A. M., August 7, for the time of Jupiter's rising; and added to 11h. 11m. gives 7h. 2m. P. M., August 7, for the time of Jupiter's setting, nearly.

Suppose it was required to find the time of the moon's setting, May 2, 1836, civil account, in the latitude of 52° N.

In the Nautical Almanac, pages iv. v., we find that the moon passes the meridian May 1d. 12h. 35m., or May 2d. 0h. 35m. A. M., civil account; her declination being about 18° S. Under the declination 18°, and opposite to the latitude 52°, stand 7h. 38m., half the time the moon is below the horizon. Subtracting this from 12h. we get half the time she is above the horizon, 4h. 22m.; adding this to 0h. 35m. we obtain the time of the moon's setting May 2d. 4h. 57m., civil account. If we subtract 4h. 22m., from 0h. 35m. + 24h., we get the time of rising May 1d. 20h. 13m. or May 1d. 8h. 13m. P. M.

If greater accuracy is required, you must find the time at Greenwich corresponding to this approximate time of her rising and setting; then find the moon's declination, and the right ascensions of the sun and moon for that moment of time. The former subtracted from the latter leaves the corrected time of the moon's passing the meridian. With these data repeat the operation. In this way we may obtain the time of rising and setting to any degree of accuracy. Instead of taking the difference of the right ascensions of the sun and moon, you may take the daily difference in the time of her coming to the meridian of Greenwich, and take a proportional part for the longitude of the place of observation (by means of Table XXVIII.) and another proportional part, for the interval between the hour of passing the meridian, and the time of rising or setting.*

It may be noted, that the numbers of Table IX. were calculated for the moment the sun's centre appears in the true horizon; allowance ought to be made for the dip, parallax, and refraction, by which the sun and stars, when near the horizon, appear in general to be elevated above half a degree above their true place, and the moon as much below her true place.

TABLE X. *For finding the Distance of any Terrestrial Object at Sea.*—The explanation and use of this table is given in Problems useful in Navigation, VIII.—XII., pages 95, 96.

TABLE X. A. For the planets is similar to Table XIV. for the sun. The parallax is found by entering at the top with the planet's horizontal parallax, and at the side with the altitude of the planet; the corresponding number is the parallax of the planet in altitude.

TABLE XI. *Table of Proportional Parts.*—The method of using this table is given in the preparations necessary for working a lunar observation page 229.

TABLE XII. *Table of Refraction.*—Explained in page 154.

TABLE XIII. *Dip of the Horizon.*—Explained in page 154.

TABLE XIV. *Sun's Parallax in Altitude.*—Explained in page 153.

TABLE XV. *Augmentation of the Moon's Semi-diameter.*—The moon's semi-diameter given in the Nautical Almanac is the same as would be seen by a spectator supposed to be placed at the centre of the earth, or nearly the same as would be seen by a spectator on the surface of the earth, when the moon is in the horizon. Now, when the moon is in the zenith of the spectator placed at the surface, her distance from him is less than when at the horizon by a semi-diameter of the earth; consequently her apparent semi-diameter must be augmented in proportion as the distance is decreased, that is, about one sixtieth part, or 16''. At intermediate altitudes between the horizon and zenith, the augmentation is proportional to the sine of the altitude, and the value for every 5° or 10° of altitude is given in Table XV. The augmentation corresponding to the altitude being found in the table, must be added to the semi-diameter taken from the Nautical Almanac for the time of observation reduced to Greenwich time, as is explained in the preparations necessary for working a lunar observation.

TABLE XVI. *Dip of the Sea at Different Distances from the Observer.*—Explained in page 155.

TABLE XVII. *For finding the Difference between 60' and the Correction of the Altitude of a Star or Planet, for Parallax and Refraction; also the corresponding Logarithm.*—The first page of this table is to be used for a star, or for the planets Jupiter and Saturn, whose parallax is small. In other cases, that page of the table is to be used, which contains, at the top, the horizontal parallax of the planet, or comes the nearest to it; the tables being calculated for every 5'' of horizontal parallax, from 0'' to 35''.

TABLE XVIII. *For finding the Difference between the Correction of the Sun's Altitude for Parallax and Refraction and 60', also a Logarithm corresponding thereto.*—The manner of taking the numbers from the two preceding tables, and the uses to which they may be applied, are explained in the preparations necessary for working a lunar observation, page 230, &c.

TABLE XIX. *For finding a Correction and Logarithm used in the First Method of work-*

* In strictness, this last correction, found by the table, ought to be decreased in the ratio of 24h. to 24h. increased by the daily difference of the time of the moon's passing the meridian.

Digitized by Google

ing a Lunar Observation.—The correction found in this table, being subtracted from 59′ 42 will leave a remainder equal to the correction of the moon's altitude for parallax and refraction. It will be unnecessary here to point out the method of taking out this correction as it is fully explained in the first pages of the table. It may not however, be amiss to observe, that, after constructing the logarithms of this table, it was concluded to subtract therefrom the greatest correction of the Table C corresponding, in order to render those corrections additive. Thus the logarithm corresponding to the alt. 30° and hor. par. 54′, was found at first to be 2372; and for the hor. par. 54′ 10″ the correction was 2358; so that if these numbers had been published, the correction for seconds of parallax would have been subtractive; but as this would have been inconvenient, it was thought expedient to subtract from each of the numbers thus calculated, the greatest corresponding correction of Table C, which in the preceding example is 12; by this means the above numbers were reduced to 2360 and 2346 respectively, and the corrections of Table C were rendered additive. In a similar manner the rest of the logarithms of the table were calculated. It is owing to this circumstance that the corrections in Table C for 0″ of parallax are greater than for any other number. Similar methods were used in calculating the other numbers of this table, and in arranging the Tables A and B.

TABLE XX. *Third Correction of the Apparent Distance.*—The manner of finding the correction from this table is explained in the first method of correcting the apparent distance of the moon from the sun, page 231; and also at the bottom of the table.

TABLE XXI. *To reduce Longitude into Time, and the contrary.*—In the first column of this table are contained degrees and minutes of longitude, in the second the corresponding hours and minutes, or minutes and seconds of time; the other columns are a continuation of the first and second respectively. The use of this table will evidently appear by a few examples.

EXAMPLE I.

Required the time corresponding to 50° 31′.

	h. m. s.
Opposite 50° in col. 1 is....................	3 20 0
31′	2 4
Sought time..................................	3 22 4

EXAMPLE II.

Required the degrees and minutes corresponding to 6h. 33m. 20s.

Opposite 6h. 32m. 0s.	......in col. 4 is.......	98° 0
1 20	......in col. 2 is.......	20
6 33 20		98 20

TABLE XXII. *Proportional Logarithms.*—These logarithms are very useful in finding the mean time at Greenwich corresponding to the true distance of the moon from the sun or star, as is explained in the examples of working a lunar observation. They may be also used like common logarithms, in working any proportion where the terms are given in degrees, minutes, and seconds; or in hours, minutes and seconds, as in the example of taking a lunar observation by one observer. The table is extended only to 3° or 3h.; and if any of the terms of a given proportion exceed 3° or 3h., you may take all the terms one grade lower; that is, reckon degrees as minutes, minutes as seconds, &c., and work the proportion as before; observing to write down the answer one grade higher; that is, you must estimate minutes as degrees, seconds as minutes, &c. Instead of taking all the terms one grade lower, you may change two of the terms only, viz. one of the middle terms and one of the extreme terms; thus the 1st and 3d or the 1st and 2d may be taken one grade less, and the fourth term will be given correctly; but if the fourth term be taken one grade less, you must, after working the proportion, write it one grade higher, as is evident. To illustrate this, we shall give the following examples:—

EXAMPLE I.

If in 15m. 10s. of time the sun rises 2° 40′, how much will it rise in 3m. 10s. at the same rate?

As	15m. 10s ..Arith. Comp....	Prop. Log.	8.9256
Is to	2° 40′	Prop. Log.	.0512
So is	3m. 10s......................	Prop. Log.	1.7547
To	33′ 24″......................	Prop. Log.	.7315

EXAMPLE II.

If the sun's declination changes 16′ 19″ in 24 hours, how much will it change in 8h. 2m.?

Here the 1st and 3d terms must be taken one grade less.

As	24m. 0s... Arith. Comp....	Prop. Log.	9.1249
Is to	16′ 19″......................	Prop. Log.	1.0426
So is	8m. 2s......................	Prop. Log.	1.3504
To	5′ 28″......................	Prop. Log.	1.5179

EXAMPLE III.

If in 12h. the moon's longitude varies 7° 1′, what will it vary in 4h. 20m.?

Here all the terms must be taken one grade less.

As	12m. 0s....Arith. Comp....	Prop. Log.	8.8239
Is to	7′ 1″......................	Prop. Log.	1.4091
So is	4m. 20s......................	Prop. Log.	1.6185
To	2′ 32″ 2‴......................	Prop. Log.	1.8515

Which, taken one grade higher, is 2° 32′ 2″, the answer required.

EXAMPLE IV.

If in 16m. the sun rises 3° 27′, how much will it rise in 3m. 10s.?

Here the 2d and 4th terms must be taken one grade less.

As	16m. 0s....Arith. Comp....	Prop. Log.	8.9482
Is to	3′ 27″......................	Prop. Log.	1.7175
So is	3m. 10s......................	Prop. Log.	1.7547
To	0′ 41″......................	Prop. Log.	2.4213

Which, taken one grade higher, is 41′, the answer required.

TABLE XXIII. *For finding the Latitude by two Altitudes of the Sun.*—The manner of using this table is explained in the examples of double altitudes given in pages 185—189.

TABLE XXIV. *Natural Sines.*—This table contains the natural sine and cosine for every minute of the quadrant to the radius 100000, and is to be entered at the top or bottom with the degrees, and at the side marked M. with the minutes: the corresponding numbers

Digitized by Google

will be the natural sine and cosine respectively, observing that if the degrees are found at the top, the same sine, cosine, and M., must also be found at the top, and the contrary if the degrees are found at the bottom. Thus 43366 is the natural sine of 25° 42′, or the cosine of 64° 18′.

We have given in this edition of the present table, in the outer columns of the margin, tables of proportional parts, for the purpose of finding nearly, by inspection, the proportional part corresponding to any number of seconds in the proposed angle; the seconds being found in the marginal column marked M., and the correction in the adjoining column. Thus, if we suppose that it were required to find the natural sine corresponding to 25° 42′ 19″; the difference of the sines of 25° 42′ and 25° 43′ is 26; being the same as at the top of the left-hand column of the table; and in this column, and opposite to 19″, in the column M., is the correction 8. *Adding* this to the above number 43366, because the numbers are *increasing*, we get 43374 for the sine of 25° 42′ 19″. In like manner, we find the cosine of the same angle to be 90108 — 4 = 90104, using the right-hand columns, and *subtracting* because the numbers are *decreasing;* observing, however, that the number 14 at the top of this column varies 1 from the difference between the cosines of 25° 42′ and 25° 43′, which is only 13; so that the table may give in some cases a unit too much, between the angles 25° 42′ and 25° 43′; but this is, in general, of but little importance, and when very great accuracy is required, the usual method of proportional parts is to be resorted to, using the actual tabular difference. Similar tables of proportional parts are inserted in this edition of Tables XXVI. XXVII. for the like purpose.

TABLE XXV. *Logarithmic Sines, Tangents, and Secants to every Point and Quarter Point of the Compass.*—This table is to be used instead of Table XXVII. when the course is given in points. The course is to be found in the side column, and opposite thereto will be the log. sine, tangent, &c.; the names being found at the top when the course is less than 4 points, otherwise at the bottom.

TABLE XXVI. *Logarithms of Numbers.*—The explanation and uses of this table are given in the article treating on logarithms in the body of the work, pages 28—33.

TABLE XXVII. *Logarithmic Sines, Tangents, and Secants.*—This table is explained in the corresponding article in the body of the work, pages 33–35.

TABLE XXVIII. *For reducing the Time of the Moon's Passage over the Meridian of Greenwich, to the Time of her Passage over any other Meridian.*—The manner of doing this is explained in the corresponding part of the body of the work, page 170.

TABLE XXIX. *Correction of the Moon's Altitude for Parallax and Refraction.*—The mean correction of the moon's altitude is given in this table for every degree of altitude from 10° to 90°. The manner of using this table is explained in pages 172, 173.

TABLES XXX. XXXI. *For finding the Sun's Right Ascension and Declination, the Equation of Time, and the Moon's Right Ascension.*—The uses of these tables will be seen by the following examples, the values for apparent noon being taken from the Nautical Almanac, together with the horary motions.

EXAMPLE I.

Required the sun's right ascension in 1836, May 1d. 6h. 35m., apparent time, astronomical account, at Greenwich.

Here the horary motion by N. A. is 9s.551.

	h. m. s.
R. A. May 1, at noon, by N. A.	2 34 39.6
Hor. motion 6h. × 9s.551	57.3
For 35m. in Table XXX	5.5
R. A. May 1d. 6h. 35m.	2 35 42.4

EXAMPLE II.

Required the equation of time in 1836, July 9d. 8h 20m. apparent time, astronomical account, at Greenwich.

Here the horary motion by N. A. is 0s.364.

	m. s.
Equation of time July 9, at noon, by N. A.	+ 4 49.3
Hor. motion 8h. × 0s.364	2.9
For 20m. in Table XXX	.1
Equation of time, 1836, July 9d. 8h. 20m.	+ 4 52.3

EXAMPLE III.

Required the moon's right ascension in 1836, Sept. 10d. 8h. 20m. 30s., *mean time*, astronomical account, at Greenwich.

	h. m. s.
By N. A. Rt. As. Sept. 10d. 9h. is	11 16 9.96
Sept. 10d. 8h. is	11 14 12.90
Horary motion in Rt. Ascen. ..	1 57.06 = 117″.06
Proportional part for 20m. 30s. Table XXX	40″
Add to R. A. Sept. 10d. 8h.	11 14 13 nearly.
Gives ☽'s Rt. Asc. Sept. 10d. 8h. 20m. 30s.	11 14 53

EXAMPLE IV.

Required the moon's right ascension in 1836, May 11d. 17h. 35m. 36s. *mean time*, astronomical account at Greenwich.

	h. m. s.
By N. A. Rt. As. May 11d. 18h. is	0 55 40.89
May 11d. 17h. is	0 53 48.72
Hor. motion in Right Ascension	1 52.17 = 112″.17
Proportional part for 35m. 36s. Table XXX., 66″ = ...	1 06
Add to Right Asc. May 11d. 17h. by N. A.	0 53 49 nearly
Gives ☾'s Rt. Asc. May 11d. 17h. 35m. 36s.	0 54 55

EXAMPLE V.

Required the sun's declination in 1836, May 1d. 6h. 35m. apparent time, astronomical account, at Greenwich.

Here the horary motion by N. A. is 44″.85.

Declination May 1, at noon, by N. A.	15° 10′ 19″ N.
Hor. motion 6h. × 44″.85	4 29
For 35m. in Table XXX	26
	15° 15′ 14″

If the declination had been *decreasing*, the horary motion would be *subtractive* instead of *additive*, as in the above example.

EXAMPLE VI.

Required the moon's declination in 1836, Sept. 10d. 8h. 20m. 30s. mean time, astronomical account, at Greenwich.

Here the motion in declination for 10m. is by N. A 140″.07

Motion for 20m. is 2 × 140″.07 = 280″.14	
Table XXX. with 140″ at top, and 30s. at side, in col. M. the correction, divided by 10, is	7 0
Motion in declina. in 20m. 30s.	287″.1 = 4′ 47″.1
Sub. from declination Sept. 10d 8h.	9 32 13″.3
☽'s declina. Sept 10d. 8h. 20m. 30s.	9° 27′ 26″.2

Digitized by Google

EXAMPLE VII.

Required the moon's declination in 1836, May 11d. 17h. 35m. 36s. mean time, astronomical account at Greenwich.

Here the motion in declination for 10m. is by N. A. 143".02.

Motion for 30m. is 143".02 × 3 =	429".1	
5m. is 143".02 × 0.5	71 .5	
Tab. XXX. 143" at top, and 36s. at side in col. M. the corr. divided by 10 is	8 .6	
Motion in declination is	509".2	= 8' 29".2
Add to declination May 11d. 17h. by N. A.		2 19 25 .9
☽'s declination May 11d. 17h. 35m. 35s.		2 27' 55".1 N.

Here the correction 8' 29".2 is *added*, because the declination is *increasing*.

If we wish to find accurately the time that any star comes to the meridian, or the time of rising or setting, we must take the sun's right ascension for noon at Greenwich, from the Nautical Almanac; then the star's right ascension from Table VIII., and with these find the approximate time of rising, setting, or coming to the meridian, by the method already given in the precepts for using Tables VIII. and IX. Then calculate the sun's right ascension for this approximate time, and repeat the operation till the assumed and calculated times agree, and we shall have the true time required.

To explain this method, we shall give the following examples:—

To find the time when a star comes to the meridian.

EXAMPLE I.

At what time was Aldebaran on the meridian of a place in the longitude of 70° 50' W., Jan. 2, 1836, sea account?

		h. m. s.
Jan. 2, sea account, is Jan. 1, N. A., on which day the sun's R. A at noon at Greenwich was		18 44 19
Aldebaran's R. A.	4h. 26m. 32s.	
Add	24	
		28 26 32
Difference is the approximate time		9 42 13
Now, calculating the sun's R. A. for this time in the long. of 70° 50' W. from Greenwich, we find it was		18 46 58
* Aldebaran's R. A. + 24h.		28 26 32
App. time of coming to the meridian		9 39 34

EXAMPLE II.

At what time was Pollux on the meridian of a place in the longitude of 70° 46' W., March 31, 1836, sea account?

	h. m. s
March 31, sea account, is March 30, N. A., on which day, at noon, the sun's right ascension was	0 36 6
This, subtracted from R. A. of Pollux	7 35 17
Gives the approximate time of southing	6 59 11
R. A. for this time in long. 70° 46' W. from Greenwich	0 37 53
Right ascension of Pollux	7 35 17
Diff. is app. time of coming to the meridian.	6 57 24

To find the time of rising or setting of a star.

Rule. Enter Table IX. with the declination of the star at the top, and the latitude of the place at the side; the corresponding number will be the time of the star's continuance above the horizon, when the latitude and declination are of the same name; but if they are of different names, the tabular number subtracted from 12h., will be the time of continuance above the horizon. Add this time to the star's right ascension, if we wish to find the time of setting; but subtract the former from the latter if we wish the time of rising. From this sum or difference subtract the sun's right ascension* corrected for the longitude of the place; the remainder will be the approximate time sought.† Enter Table XXXI. with the distance of this approximate time from noon, and the horary variation of the sun's right ascension: the correction corresponding is to be added to the approximate time in the forenoon, but subtracted in the afternoon, and we shall have the corrected time of rising and setting.

EXAMPLE I.

At what time did the star Aldebaran set May 24, 1836, sea account, in the latitude of 38° 53' N. and the longitude of 77° W., or 5h. 8m. W.?

The star's declination was 16° 10' N., and the latitude 38° 53' N., corresponding to which in Table IX. is		6h. 54m.
Star's right ascension		4 26
Sum		11 20
May 24, sea acc., or May 23 by N. A. at noon, sun's R. A.	4h. 1m. Hor. var. 10s.	
Corr. for long. 5h. 8m. W..	1	
Sum subtract		4 2
Remains approximate time of setting		7 18
Corr. in Tab. XXXI. for 7h. 20m., sub.		1
Corrected time of setting, P. M.		7 17

EXAMPLE II.

At what time did the Dog-Star Sirius rise in the latitude 39° 20' N., and the longitude of 76° 50' W = 5h. 7m. 20s. W., Jan. 2, 1836, sea account?

The star's declination is 16° 29' S., and the latitude is 39° 20' N., corresponding to which in Table IX is nearly		6h. 56m
Which subtracted from		12 0
Leaves the time of the star's being above the horizon		5 4
Subtract from star's R. A.		6 38
Remainder		1 34
Add		24
Sum		25 34
Jan. 2, sea acc. or Jan. 1, by N. A. at noon, sun's R. A.	18h. 44m. Hor. var. 11s	
Corr. for long. 5h. 7m. 20s. W.	1	
Subtract the sum		18 45
Remains approxim. time of rising		6 49
Corr. in Tab. XXXI. for 6h. 49m., sub.		1
Corr. time of rising in the afternoon		6 48

* Increasing the number from which the subtraction is to be made, by 24 hours, when necessary.

† Rejecting 24 hours when it exceeds 24 hours. If the time of rising or setting be more than 12h., it will be after midnight; but if less than 12h., it will be before midnight.

Digitized by Google

TABLE XXXII. *Variation of the Sun's Altitude in one Minute from Noon.*

TABLE XXXIII. *To reduce the Numbers of Table XXXII. to other given Intervals of Time from Noon.*

The method of using the two preceding tables is explained in the examples of finding the latitude by one altitude taken near noon, given in the body of the work, pages 201—203.

TABLE XXXIV. *Errors arising from a Deviation of 1′ in the Surfaces of the Central Mirror.* This table shows the error arising in measuring an angle by an instrument of reflection from a deviation of 1′ in the parallelism of the surfaces of the central mirror, the line of intersection of those surfaces (produced if necessary) being perpendicular to the plane of the instrument. If the line of intersection be inclined to that plane, the numbers in the table must, in general, be decreased in proportion to the sine of the angle of inclination.

The second, third, and fourth columns of the table are calculated upon the supposition that the surface of the horizon mirror is inclined 80° to the axis of the telescope, or that the angle intercepted between the ray incident on the horizon glass and the corresponding reflected ray passing through the telescope is 20°, which is the case in circular instruments of De Borda's construction, and on this supposition the errors of an instrument in measuring different angles may be ascertained by the rules in pages 136 and 143; when the intercepted angle is greater or less than 20°, which is the case in most sextants and quadrants, the error in any measured angle corresponding to an inclination of the surfaces of 1′, may be obtained as follows:—

Find in the first column the intercepted angle, and the sum of that angle and the observed distance; take the corresponding corrections from column 5th, and their difference will be the sought correction.

In a circular instrument you must find in the side column the sum and the difference of the intercepted angle and observed angle, and take out the corresponding corrections from column 5th: half their difference will be the sought correction. Having thus found the correction corresponding to 1′, you may find the correction for other angles as in pages 136 and 143.

TABLE XXXV. *Correction for a Deviation of the Telescope of an Instrument of Reflection from the Parallelism to the Plane of the Instrument.*—The uses of this table are explained in pages 135, and 143.

TABLE XXXVI. *Correction of the Mean Refraction for Various Heights of the Barometer and Thermometer.*—The use of this table is explained in page 154.

TABLE XXXVII. *Latitudes and Longitudes of the Fixed Stars.*—This table contains the latitudes and longitudes of the principal fixed stars, adapted to the beginning of the year 1830, with the annual variations for precession and the secular equation, by which the mean values at any time may be obtained, in like manner as the right ascensions and declinations are from Table VIII.; by *adding* the correction of longitude *after* 1830, subtracting before 1830, and applying the correction of latitude with the same sign as in the table after 1830, but with a contrary sign before 1830.

EXAMPLE I.

Required the longitude and latitude of *a* Pegasi, July 16, 1828.

Long. by Table XXXVII.........	11s.	21°	07′	05″	Latitude by Table XXXVII..........	19°	24′	45″	N
Variation 1 year, 5¼m., sub.			1	13	Variation 1 year, 5¼m., sub...........			0	
Long. July 16, 1828................	11	21	05	52	Latitude July 16, 1828................	19	24	45	N

EXAMPLE II.

Required the longitude and latitude of *a* Pegasi, July 1, 1832.

Long by Table XXXVII..........	11s.	21°	07′	05″	Latitude by Table XXXVII.........	19°	24′	45″	N
Variation 2½ years, add...........			2	5	Variation 2½ years, add.............			0	
Long. July 1, 1832................	11	21	09	10	Latitude July 1, 1832................	19	24	45	N

The latitudes and longitudes, thus obtained, are the mean values. When great accuracy is required, the corrections for the equation of the equinoxes, Table XL. and aberration Table XLI. must be applied.

TABLE XXXVIII. *Reduction of Latitude and Horizontal Parallax.*—This table contains the corrections to be subtracted from the latitude of the place of observation, and from the horizontal parallax of the moon, given in the Nautical Almanac, in calculating eclipses of the sun or occultations. Thus, if the latitude of the place was 40°, and the moon's horizontal parallax 57′, the correction of latitude would be nearly —11′ 18″, and that of parallax —4″.7, so that the reduced latitude would be 39° 48′ 42″, and the reduced parallax 56 55″.3. These values are to be used in occultations; but in eclipses of the sun, this parallax is to be further decreased by 8″.6 for the sun's parallax. When the latitude is not given exactly in the table, the two nearest numbers must be found, and a proportional part of their difference is to be applied to one of the numbers, as usual. In calculating this table, the ellipticity of the earth was supposed equal to $\frac{1}{300}$, as in the third edition of La Lande's Astronomy, and in Vince's Astronomy. This value differs but little from $\frac{1}{304.8}$ and $\frac{1}{305.05}$, deduced by La Place from two lunar equations in the third volume of his immortal work, *La Mécanique Céléste*. In the second volume of the same work, he calculated the ellipticity to be $\frac{1}{336}$ from the lengths of pendulums observed in different latitudes: this calculation corrected for a small mistake in the numerical co-efficient of y in the

Digitized by Google

tenth of his equations A″ becomes $\frac{1}{315}$, which does not differ very much from the value assumed in this table.

TABLE XXXIX. *Aberration of the Planets.*—This table contains the aberration of the planets, to be applied to the *true* longitude or latitude, with the *same* sign as in the table. The argument at the side is the elongation of the planet from the sun; that is, the difference of their geocentric longitudes, or its supplement to 360°. Thus, on July 19, 1820, the longitude of the sun was 3s. 26° 38′, the geo. long. of Venus 4s. 13° 23′, their difference 16° 45′ is the elongation or distance from the inferior conjunction, corresponding to which is the aberration + 3″ to be applied to the true longitude given by the tables to obtain the apparent longitude. The aberration of Mercury is given at its greatest, least and mean distances from the sun. At the intermediate places, a proportional part of the differences of the nearest tabular numbers must be applied.

TABLES XL. and XLI. *Equation of the Equinoxes and Aberration in Longitude.*—Table XL. contains the equation of the equinoxes in longitude common to all the heavenly bodies. The argument is the longitude of the moon's ascending node; the signs of longitude being found at the top or bottom, and the degrees at the side, the corresponding number with its sign is the equation of the equinoxes in longitude.

Table XLI. contains the aberration of the stars in longitude and latitude, to be calculated by the rules at the bottom of the tables; the signs of the argument being found at the top, and the degrees at the side,* taking proportional parts for minutes. The corrections of longitude found in these tables are to be applied, with their signs, to the mean longitude found in Table XXXVII., and the correction of latitude, Table XLI., is to be applied to the mean latitude deduced from Table XXXVII. Thus, on July 16, 1830, by the examples at the bottom of Tables XL. XLI., the equation of the equinoxes was — 5″.3, and the aberration in longitude + 11″.3; these corrections being applied to the mean longitude of the star deduced from Table XXXVII., 11s. 21° 7′ 32″, gives its apparent longitude 11s. 21° 7′ 38″. In a similar manner the aberration in latitude, — 5″.6, found at the bottom of Table XLI., applied to the mean latitude, 19° 24′ 45″ N., deduced from Table XXXVII., gives the apparent latitude of the star 19° 24′ 39″ N.

TABLES XLII. XLIII. *Aberration and Nutation in Right Ascension and Declination.*—Table XLII. contains the aberration, and Table XLIII. the nutation in right ascension and declination, to be found by the rules at the bottom of the tables, and applied, with their signs, to the mean values deduced from Table VIII. Thus, by Table VIII., the right ascension of *α* Pegasi, July 16, 1830, was 22h. 56m. 20s., and its declination 14° 18′ N. The aberration of right ascension in time was nearly + 0s.8, in declination — 0″.8; the nutation in right ascension in time — 0s.1, in declination + 0″.5, as appears by the examples at the bottom of the tables. These corrections being applied to the mean values, give the apparent right ascension 22h. 56m. 21s., and the apparent declination 14° 18′ N. The equation of the obliquity of the ecliptic may be calculated by the rule at the bottom of the table Thus, on July 16, 1830, the equation was — 9″.1, which, applied to the mean obliquity 23° 27′ 42″.0, gives the apparent obliquity 23° 27′ 32″.9.

TABLE XLIV. *Augmentation of the Moon's Semi-diameter.*—This table is divided into four parts, and is useful in finding the augmentation of the moon's semi-diameter by means of the altitude and longitude of the nonagesimal when the moon's altitude is unknown The precepts for this calculation are given at the bottom of the table, and for further illustration another example is added, in which it is required to find the augmentation at the commencement of the occultation calculated in Problem VII. of the Appendix, when the ☽'s S. D. by the Nautical Almanac was 16′ 18″.9, her true latitude 1° 55′ 11″ S., parallax in lat. 10′ 23″.6, altitude of the nonagesimal 81° 17′ 32″, and the moon's apparent distance from the nonagesimal 51° 38′ 26″, as in Example III. Prob. V. Appendix In this case the arguments of Part I. are 81° 17′ 32″ + 51° 38′ 26″, or nearly 4s. 12° 56′ and 0s 29° 39′, and the corresponding corrections + 6″.00, + 4″.05, whose sum is 10″.05. This in Part II. gives + 0″.10. In Part III., with the moon's true latitude, 1° 55′ 11″ S., and her par. in lat. 10′ 23″.6, the correction is — 0″.10. The sum of these three parts is + 10″.05, which being found at the side of Part IV., and the moon's horizontal S. D. 16′ 18″.9 at the top, gives the corresponding correction + 0″.40. This connected with the three former parts + 10″.05, gives the sought augmentation 10″.45, or 10″.4, as in the example Prob. VII. Appendix It may be observed that the calculation by Problem IV. will sometimes produce the supplement of the altitude of the nonagesimal; but this requires no alteration in the rule, since the result is the same whether the altitude or its supplement is used.

TABLE XLV. *Equation of Second Differences.*—This table contains the equation of the second differences of the moon's motion, or the correction to be made on account of her unequal velocity between the times marked in the Nautical Almanac. The manner of applying this correction is taught in Problems I. II. III. of the Appendix.

TABLE XLVI. *Variation of the Altitude of an Object, arising from a Change of* 100 *Seconds in the Declination.*—This table is useful in finding the latitude by double altitudes of the sun, or any other object. It is explained in the precepts for such calculations, pages 189, 190, 191, &c. The table is to be entered at the top with the latitude of the place, and

---

* The degrees in this and the following tables are to be found in the column marked D on the same horizontal line with the signs. Thus if the signs are at the top of the table, the degrees must be found in the left column, otherwise in the right.

Digitized by Google

at the side with the declination and altitude of the body; the corresponding number is the variation of the altitude, in seconds, for a change of 100″ in the declination.

TABLES XLVII. XLVIII. *are used in finding the First, Second and Third Corrections in Lyon's Improved Method of working a Lunar Observation.*—The first of these tables gives the first and second corrections. The first correction is always taken out with the degrees and minutes marked at the top of the table. The second correction is also taken at the top when the apparent distance exceeds 90°, but at the bottom when the apparent distance is less than 90°.

TABLES XLIX. L. *are used in finding the Correction for Parallax in Lyon's Improved Method of working a Lunar Observation.*—The first of these tables gives the correction, supposing the parallax to be 35″. It is to be entered at the top with the apparent distance, and at the side with the altitudes of the object; the corresponding number is the correction for the horizontal parallax, 35″. This is to be found in the side column of Table L., and the horizontal parallax at the top; the corresponding number is the actual parallax in altitude, which is to be applied, with the same sign as in Table XLIX., to the apparent distance. Thus, if the app. dist. = 60°, *'s alt. = 25°, ☽'s alt. = 45°, the correction in Table XLIX. is — 20″; and if the planet's horizontal parallax be 15″, the corresponding correction in Table L. will be — 9″; to be applied as a third correction to the apparent distance.

TABLE LI. To change mean solar time into sideral time.

TABLE LII. To change sideral time into mean solar time.

TABLE LIII. Gives the variation of the compass very nearly as in the chart of P. Barlow.

TABLE LIV. *Table of Latitudes and Longitudes.*—This table (as observed in the Preface) has been completely revised for this edition, and the latitudes and longitudes of a great number of places are added to those given in some of the former editions of this work

TABLE LV. *Tide Table.*—The explanation and uses of this table are given in the body of the work, in treating of the manner of computing the times of the tide, page 121, &c.

TABLE LVI. Extracts from the Nautical Almanac of the numbers used in the examples of lunar observations &c.

TABLE LVII. shows, nearly, the error in Longitude in miles and tenths of a mile, occasioned by an error of one mile in the Latitude.

Thus, when the sun's altitude is 30°, the Latitude 30°, and the Polar distance 100°, the error is 8 tenths of a mile.

The error affects the Longitude as follows:

When in *West* Long. and the time is found in Col.	A. M. P. M.	the Long. is	decreased. increased.	When the correction is marked X the Longitude is	increased. decreased.
When in *East* Long. and the time is found in Col.	A. M. P. M.	the Long. is	increased decreased.	When the correction is marked X the Longitude is	decreased. increased

Digitized by Google

APPENDIX,

CONTAINING

METHODS OF DETERMINING THE LONGITUDE BY OBSERVATIONS OF ECLIPSES, OCCULTATIONS, &c.

The longitude of a place may be determined in a very accurate manner, by observing the beginning or end of a solar eclipse, or occultation of a fixed star by the moon, or the difference between the times that the moon and a known fixed star pass the meridian. These observations, when made on land with a good telescope and well-regulated time-keeper furnish by far the most accurate method of determining the longitude, and when made on board a ship without a telescope, will in general give it, with a greater degree of accuracy than any other method. For this reason we have inserted, in this Appendix, the usual rules of calculating such observations, by means of the Nautical Almanac. The first thing to be taken notice of, is the method of determining the longitude, latitude, &c. of the moon or other object, having regard to the unequal velocity between the times for which these quantities are given in the Nautical Almanac. This calculation is rendered much more simple by making use of the signs + and —, and performing addition and subtraction as in the introductory rules of algebra; and as it is possible that these rules may not be familiar to some readers of this work, we have given an explanation, as far as will be necessary, in the present problems.

Quantities *without a sign*, or with the sign + prefixed, are called *positive* or *affirmative*, as 7 or + 7; and those to which the sign — is prefixed, are called *negative*, as — 7. *Addition of quantities having the same sign, that is, all affirmative or all negative, is performed by adding them as in common arithmetic, and prefixing the common sign.* Thus the sum of + 4 and + 3 is + 7. The sum of — 4, — 3, and — 5, is — 12. *When the quantities have not the same sign, the positive quantities must be added into one sum, and the negative into another as above; the difference of these two sums, with the sign of the greater sum prefixed, will be the sum of the proposed quantities.* Thus the sum of + 14, — 7, + 5, and — 2, is found by adding + 14, + 5, whose sum is + 19; and then — 7 and — 2, whose sum is — 9; the difference of 19 and 9 is 10, to which must be prefixed the sign of the greater number, 19, which is +, so that the sought sum is + 10. The following examples will illustrate these rules:—

Add + 4	Add + 4′ 10″	Add — 4′ 10″	Add — 4′ 10″	Add + 1	Add + 6′ 0″
+ 3	+ 2 5	— 2 5	+ 2 5	— 1	— 2 15
+ 7	Sum + 6 15	Sum — 6 15	Sum — 2 5	Sum 0	+ 4 13
— 2					— 3 7
Sum + 12					Sum + 4 51

Subtraction is performed by changing the sign of the number to be subtracted from + to —, or from — to +; and then adding the numbers by the preceding rule. Thus to subtract + 3 from + 7, the sign of + 3 must be changed, and the numbers — 3 and + 7 added together as in algebra, which, by the preceding rule, gives + 4; and if it were required to subtract — 3 from 7, the sign of — 3 must be changed, and + 3, + 7 added together; the sum + 10 represents the sought difference. It is not usual to make an actual change of the sign in any proposed question, it being sufficient to suppose the number to be subtracted to have a different sign from that prefixed to it, and to perform the operation accordingly. To illustrate this, the following examples are added:—

From + 4′ 10″	From + 4′ 10″	From — 4′ 10″	From — 4′ 10″	From + 1	From — 1	From + 1
Sub + 2 5	Sub. — 2 5	Sub. — 2 5	Sub. + 2 5	Sub. — 1	Sub. — 1	Sub. + 1
Rem + 2 5	Rem. + 6 15	Rem. — 2 5	Rem. — 6 15	Rem. + 2	Rem. 0	Rem. 0

From 108	From — 108	From 108	From — 108	From — 201
Sub. 201	Sub. — 201	Sub. — 201	Sub. 201	Sub. 108
Rem. — 93	Rem. + 93	Rem. + 309	Rem. — 309	Rem. — 309

Observing that when no sign is annexed to a quantity, the sign + is always understood to be prefixed.

PROBLEM I.

To find the longitude, latitude, &c. of the moon at any given time at Greenwich, having regard to the unequal velocity between the times marked in the Nautical Almanac; the intervals of these times being 12 hours.

Digitized by Google

RULE

Take from the Nautical Almanac the two longitudes, latitudes, &c. next preceding the given time at Greenwich, and the two immediately following it, and set them down in succession below each other, prefixing the sign + to the southern latitudes or declinations, and the sign — to the northern. Subtract each of these quantities from the following for the *first differences*, and call the middle term arc A; subtract each first difference from the following for the *second differences*, and take the half sum or mean of them, which call the arc B, noting the signs of the quantities as in algebra.

Find the difference between the given time and the second time taken from the Nautical Almanac, which call T; then to its logarithm add the log. of A and the constant logarithm 5.36452; the sum, rejecting 10 in the index, will be the logarithm of the *proportional part*,* to which prefix the sign of the arc A; observing to express all these quantities in seconds.

Enter Table XLV. with the arc B at the top and the time T at the side:† opposite to this will be the correction of second differences, to which prefix a *different sign* from that of the arc B, and place it under the proportional part found above, and the second quantity taken from the Nautical Almanac, and connect these three quantities together as in addition in algebra: the sum will be the sought longitude, latitude, &c.; the latitude or declination being *south*, if it has the sign +; *north*, if it has the sign —.

EXAMPLE I.

Required the longitudes and latitudes of the moon, December 12, 1808, at 15h. 48m. 29s. and 17h. 1m. 29s. app. time by astronomical computation at Greenwich, which correspond to the immersion and emersion of Spica, calculated in Problem VII.

1808. Dec D	☽ long N A s. ° ′ ″	1st diff. ° ′ ″	2d diff. ′ ″	☽ latit. S. ° ′ ″	1st diff. ′ ″	2d diff ″
12 noon.	6 10 45 20			+2 40 58		
		7 6 16			—34 21	
12 midn.	6 17 51 36		+5 2	+2 6 37		—2 24
		A 7 11 18			A —36 45	
13 noon.	6 25 2 54		+4 47	+1 29 52		—1 40
		7 16 5			—38 34	
13 midn.	7 2 18 59		B = +4 54.5	+0 51 18		B = —2 06.5

IMMERSION.

Constant 5.36452	.... 5.36452
T = 3h. 48m. 29s. = 13709s.....Log. 4.13701	.... 4.13701
A = 7 11 18 = 25878 ....Log. 4.41293	A = — 36′ 45″ = — 2205″ .....Log. 3.34341
+ 2 16 52.2 = 8212.2....Log. 3.91446	— 11 39.7 = — 699.7.....Log. 2.84494
+ 6 17 51 36 Second longitude.	+ 2 6 37 Second latitude.
— 31.9 Table XLV. B = 4′ 54″.5	+ 13.7 Table XLV. B = — 2′ 6″.5
6 20 7 56.3 ☽'s longitude.	+ 1 55 11 0 ☽'s latitude south

EMERSION.

Constant 5.36452	.... 5.36452
T = 5h. 1m. 29s. = 18089s.......Log. 4.25742	.... 4.25742
A 7 11 18 = 25878 ....Log. 4.41293	A = — 36′ 45″ = — 2205″ ...Log. 3.34341
+ 3 0 36.0 = 10836 ....Log. 4.03487	— 15 23.3 = — 923.3....Log. 2.96535
+ 6 17 51 36 Second longitude.	+ 2 6 37 Second latitude.
— 35.9 Table XLV. B. = 4′ 54″.5	+ 15.4 Table XLV. B. = — 2′ 6″.5
6 20 51 36.1 ☽'s longitude.	+ 1 51 29.1 ☽'s latitude south.

These quantities are made use of in Problem VII.

EXAMPLE II.

Required the longitudes and latitudes of the moon, June 16, 1806, at 2h. 49m. 50s.1, and 5h. 34m. 6s.6, app. time, astronomical account at Greenwich, which correspond nearly to the beginning and end of the total eclipse of the sun as observed at Salem.

1806. June.	☽ long. N. A. s. ° ′ ″	1st diff. ° ′ ″	2d diff. ′ ″	☽ lat. N. A. ° ′ ″	1st diff. ′ ″	2d diff ″
15d. midn.	2 14 48 58			—1 14 6		
		7 17 21			+39 53	
16 noon.	2 22 6 19		+3 32	—0 34 13		+53
		A 7 20 53			A +40 46	
16 midn.	2 29 27 12		+2 42	+0 6 33		+9
		7 23 35			+40 55	
17 noon.	3 6 50 47		B = +3 7	+0 47 28		B = +31

* This correction may also be found by proportion, by saying, As 12 hours are to the time T, so is the arc A to the sought proportional part; and this method is the shortest when T is an aliquot part of 12 hours. Thus, if T be 3, 6, or 9 hours, the proportional part will be ¼, ½, or ¾ of the arc A respectively. This method is made use of in Problem XVII. in interpolating the distance of the moon and sun.

† If the arc B consists of minutes and seconds, the correction for minutes, tens of seconds, and units of seconds, must be found separately: the sum of these three parts will be the sought correction. Proportional parts for the minutes of the time T may be taken in finding the correction of this table, when necessary. In this rule, part of the correction of the third difference is neglected. This part never exceeds $\frac{1}{124}$ of the third difference, and rarely amounts to a small fraction of a second.

Digitized by Google

BEGINNING AT 2h. 49m. 50s.1 = T

Second longitude		2s.	22°	6′	19″	Second latitude N.	—	0°	34′	13″
A 7° 20′ 53″ Prop. part	+		1	43	59.8	A 40′ 46″ Prop. part	+		9	27.3
B 3 7 Table XLV	—				16.8	B 31 Table XLV	—			2.8
☽'s longitude		2	23	50	2.0	☽'s latitude N.	—	0	24	36.2

END AT 5h. 34m. 6s.6 = T.

Second longitude		2s.	22°	6′	19″	Second latitude N.	—	0°	34′	13″
A 7° 20′ 53″ Prop. part	+		3	24	35.3	A 40′ 46″ Prop. part	+		18	55.0
B 3 7 Table XLV	—				23.2	B = 31″ Table XLV	—			3.8
☽'s longitude		2	25	30	31.1	☽'s latitude N.	—	0	15	21.8

The proportional parts of the arc A were calculated in this example by arithmetic without logarithms. By observations of the eclipse on that day, it was found that the moon's longitude was too great by 58″.5, and her latitude too great by 11″.4. These corrections are applied to the above longitudes and latitudes, in calculating the eclipse in Problem VI.

Remark 1. It will not be necessary to take notice of the second differences in calculating the parallax or semi-diameter of the moon, or any of the solar elements useful in calculating an eclipse or occultation. In this case, the quantities immediately preceding and following the proposed time at Greenwich, must be taken from the Nautical Almanac; and their difference will be the arc A; also the difference between the proposed time and that taken first from the Nautical Almanac is to be called the time T. Then, by proportion, as the interval between the times taken from the Nautical Almanac is to the time T, so is the arc A to the correction to be applied to the first quantity taken from the Nautical Almanac; additive if increasing, subtractive if decreasing. This correction may also be found by logarithms as above, using the constant logarithms 5.36452 if the interval of the times in the Nautical Almanac is 12 hours, and 5.06349 if the interval is 24 hours. The proportional part of the moon's parallax and semi-diameter may also be found by Table XI., and that of the solar elements by Tables XXX. XXXI., as taught in the explanation of these tables; these calculations being sometimes much facilitated in the new form of the Nautical Almanac, by means of the horary motions, which are given for several of the elements. To exemplify this, the rest of the quantities requisite in calculating the eclipse and occultation (Problem VI. VII.) are here found.

EXAMPLE III.

1808.	☽ S. D.		☽ H. P.		1808.	⊙ long.				⊙ R. A.			
Dec. 12, midnight	16′	17″	59′	46″	Dec. 12, noon	8s.	20°	29′	4″	17h.	18m.	4s	.4
Dec. 13, noon	16	23	60	6	13, noon	8	21	23	10	17	22	29	.5
Difference A.		6		20	Difference A.		1	1	6		4	25	1
Pro. part T = 3h. 48m. 29s.		1.9		6.3	Pro. part T = 15h. 48m. 29s.			40	15		2	54	6
Corresponding values	16	18.9	59	52.3	Corresponding values	8	21	2	19	17	20	59	.0
Pro. part T = 5h. 1m. 29s.		2.5		8.4	Pro. part T = 17h. 1m. 29s.			43	21		3	8	.1
Corresponding values	16	19.5	59	54.4	Corresponding values	8	21	5	25	17	21	12	.5

EXAMPLE IV.

1806.	☽ S. D.		☽ H. P.		1806.	⊙ long.			⊙ R. A.			
June 16, noon	16′	27″	60′	21″	June 16, noon	84°	34′	18″	5h.	36m.	20s.	6
16, midnight	16	30	60	34	17, noon	85	31	35	5	40	30	.0
Differences A.	+	3	+	13	Differences A.		57	17		4	9	.4
Pro. part T = 2h. 49m. 50s.1	+	0.7	+	3.1	Pro. part T = 2h. 49m. 50s.1	+	6	45.4		+	29	.4
Corresponding values	16	27.7	60	24.1	Corresponding values	84	41	3.4	5	36	50	.0
Pro. part T = 5h. 34m. 6s 6	+	1.4	+	6.0	Pro. part T = 5h. 34m. 6s.6	+	13	17.5		+	57	.9
Corresponding values	16	28.4	60	27.0	Corresponding values	84	47	35.5	5	37	18	.5

The semi-diameters thus found must be decreased 2″ for inflexion, and augmented by the correction Table XLIV. in calculating an eclipse or occultation by Problem XIII., or in deducing the longitude from observations by Problems VI. VII. VIII. or IX. We may, however, observe, that some astronomers neglect the correction of 2″ for inflexion.

The sun's semi-diameter by the Nautical Almanac, June 13, 1806, was 15′ 46″.3, and June 19, 1806, was 15′ 45″.9. Hence, at the above time, it was 15′ 46″.1. This, in eclipses of the sun, must be decreased 3½″ for irradiation.

Remark 2. The above rule for calculating the second differences of the lunar motions where the intervals in the Nautical Almanac are 12 hours, may be made use of when the intervals are any number of days, as is the case with the elements of the motions of the planets, by taking two longitudes, latitudes, &c. before, and two after, the given time at Greenwich, and thence deducing the arcs A. B, and the longitudes, latitudes, &c., and then making use, instead of T, of the *quotient* of the difference between the given time and that marked in the Nautical Almanac against the second longitude, &c. divided by the number of half days in the given *interval*. Thus, if the interval is 1 day, the divisor is 2; if the interval is 4 days, the divisor is 8; and if the interval is 5 days, the divisor is 10. In like manner, if the interval is 3 hours, we must *multiply* by 4; if the interval is 1 hour, we must *multiply* by 12, or, more simply, *divide the minutes and seconds of time* by 5, and consider the resulting quotient, or value of T, as *hours and minutes* respectively. To illustrate this, we shall give the following examples:—

Digitized by Google

EXAMPLE V.

Required the right ascension of Venus, 1836, August, 23d. 16h. 40m. mean time, astronomical account, at Greenwich.

Times.	Right Ascen. h. m. s.	1st diff. m. s.	2d diff. s.
August 22	7 44 23.51		
23	7 45 24.05	1 00.54	
24	7 46 32.84	A = 1 08.79	8.25
25	7 47 49.65	1 16.81	8.02
			B = 8.13

Second right ascension............		7h. 45m. 24s.05
A = 1m. 08s.79	Proportional part...	47 .77
B = 8s.13	Table XLV.......	— .83
Venus's right ascension............		7h. 46m. 10s.99

In this example, the intervals in the Nautical Almanac being 1 day, we must divide the time, 16h. 40m., by 2, to get T = 8h 20m.

EXAMPLE VI.

Required the declination of Mars, 1836, June, 14d. 13h. 30m., mean time, astronomical account, at Greenwich.

Times.	Declinations. ° ′ ″	1st diff. ′ ″	2d diff. ″
June 13	15 14 19.2		
14	15 27 56.9	13 37.7	
15	15 41 25.0	A = 13 28.1	— 9.6
16	15 54 43.4	13 18.4	— 9.7
			B = — 9.6

Second declination................		15° 27′ 56″.9 N
A = 13′ 28″.1	Proportional part....	7 34 .6
B = — 9″.6	Table XLV........	1 .2
Mars's declination		15° 35′ 32″.7 N

In this example, as in the last, we divide the time, 13h. 30m., by 2, to get T = 6h. 45m.

EXAMPLE VII.

Required the logarithm of the distance of Jupiter from the earth, 1836, June, 2d. 8h., mean time, astronomical account, at Greenwich.

Times.	Log. Dist.	1st diff.	2d diff.
June 1	0.7803725		
2	0.7810545	6820	
3	0.7817232	A = 6687	— 133
4	0.7823787	6555	— 132
			B = — 132

Second distance..........................		0.7810545
A = 6687	Proportional part.............	2228
B = — 132	Table XLV....................	15
Log. distance Jupiter and Earth..........		0.7812788

In this example, we also divide the time, 8h., by 2, to get T = 4h.

EXAMPLE VIII.

Required the moon's declination, 1836, January, 16d. 9h. 45m. 50s., mean time, astronomical account, at Greenwich.

Times. d. h.	Declination S. ° ′ ″	1st diff. ″	2d diff. ″
Jan. 16 8	26 26 58.3		
9	28 08.4	70.1	
10	29 06.4	A = 58.0	— 12.1
11	29 52.3	45.9	— 12.1
			B = — 12.1

Second declination		26° 28′ 08″.4 S
A = 58″.0	Prop. part Tab. XXX.	44 .3
B = — 12″.1	Table XLV	1 .1
Moon's declination................		26° 28′ 53″.8 S.

In this example, the time, 45m. 50s., divided by 5, and changing *minutes* into *hours*, &c gives T = 9h. 10m., which is used in entering Table XLV. with B = — 12″.1, to find the corresponding correction, 1″.1. We may, however, remark, that the second differences of the right ascensions and declinations of the moon may generally be neglected as insensible, because these quantities are given in the Nautical Almanac for every hour, and their second differences are quite small. The same is to be observed relative to the sun's longitude, right ascension, the equation of time, &c. The second difference of the sun's declination may sometimes be 3″ or 4″, but is, in general, insensible. The second differences of the log. radius vector must be taken, if we wish to obtain the logarithm correct in the seventh decimal place. We can always judge of the necessity of using the second differences, by observing that the greatest error from neglecting them altogether is equal to $\frac{1}{8}$ B. Thus, in the last example, the greatest error from neglecting the consideration of the second differences is $\frac{1}{8}$ B = $\frac{1}{8}$ × 12″.1 = 1″.5.

PROBLEM II.

To find the horary motion of the moon in longitude, latitude, &c. at any given time at Greenwich; supposing the intervals of the times in the Nautical Almanac to be 12 hours.

RULE.

Take from the Nautical Almanac the four longitudes, latitudes, &c., two immediately preceding the given time at Greenwich, and two immediately following. *Prefix the sign + to the southern latitudes or declinations, and the sign — to the northern.* Then find the first and second differences, the arc B, and the time T, as in Problem I. The mean of the two first differences, noticing the signs as in algebra, will be the *approximate* motion in 12 hours.

To the proportional logarithm of one fourth part of the time T, add the proportional logarithm of the arc B: the sum will be the proportional logarithm of the correction of the approximate motion, to be applied to it with *the same sign as the arc B*, and the corrected

Digitized by Google

motion of the moon in 12 hours will be obtained,* which, being divided by 12, will give the horary motion.

EXAMPLE I.

Required the horary motions of the moon in longitude, Dec. 12, 1808, at 15h. 48m. 29s., and 17h. 1m. 29s., apparent time, at Greenwich.

This corresponds to Example I., preceding, in which T is 3h. 48m. 29s., or 5h. 1m. 29s. The two *first differences* in longitude are 7° 6′ 16″, and 7° 11′ 18″; their mean, 7° 8′ 47″, is the approximate motion in 12 hours, and the arc B is 4′ 54″.5. The rest of the calculation is as follows:—

At 15h. 48m. 29s. T = 3h. 48m. 29s.				
Arch B		4′	54″.5	Prop. Log. 1.5644
¼ T		57	7	Prop. Log. .4985
Corr. +		1	33	Prop. Log. 2.0629
Approx. motion	7	8	47	
Motion 12 hours	7	10	20	
In 1 hour......		35	51.7	

At 17h. 1m. 29s. T = 5h. 1m. 29s.				
....				1.5644
¼ T 1h. 15m. 22s.				Prop. Log. .3781
Corr. +		2	3	Prop. Log. 1.9435
Approx. motion ..	7	8	47	
Motion 12 hours..	7	10	50	
In 1 hour		35	54.2	

In a similar manner, if the horary motion in latitude was required at 12d. 17h. 33m., the two *first differences* in latitude are — 34′ 21″, and — 36′ 45″; their mean, — 35′ 33″, is the approximate motion in 12 hours. The correction found by the above rule with the time T, 5h. 33m., and the arc B = — 2′ 6″.5, is — 59″, whence the true motion in 12 hours is — 36′ 32″, which, divided by 12, gives the horary motion — 3′ 2″.7. The negative sign — indicates that the north polar distance is decreasing, the positive sign + that it is increasing In the present example, the north polar distance was decreasing, and as the latitude was south, it was also decreasing, as is evident.

EXAMPLE II.

Required the horary motions of the moon in longitude, June 16, 1806, at 2h. 49m. 50s.1 and 5h. 34m. 6s.6, apparent time, by astronomical computation, at Greenwich.

This corresponds to Example II. preceding, in which T is 2h. 49m. 50s.1, or 5h. 34m 6s.6; the two first differences are 7° 17′ 21″, and 7° 20′ 53″, the mean of which, 7° 19′ 7′ is the approximate motion in 12 hours. The arch B is + 3′ 7″.

At 2h. 49m. 50s.1 = T.				
Arch B = +		3′	7″	Prop. Log. 1.7616
¼ Time T =		42	27	Prop. Log. .6274
Correction +		0	44	Prop. Log. 2.3890
Approx. motion.....	7	19	7	....
Motion in 12 hours..	7	19	51	
Motion in 1 hour....		36	39.2	

At 5h. 34m. 6s.6 = T.				
....				.. 1.7616
¼ T = 1h. 23m. 32s.				Prop Log. .3334
Correction +		1	27	Prop. Log. 2.0950
....	7	19	7	
Motion in 12 hours	7	20	34	
Motion in 1 hour..		36	42.8	

REMARKS.

1. When it is required to find the motion of the moon in longitude or latitude, for any given interval of time, the motion in 12 hours must be found for the middle of that interval.

2. In calculating an occultation of a star by the moon, the relative horary motion in longitude is the same as the horary motion of the moon, because the star is at rest; but in calculating a solar eclipse, the sun's horary motion must be found from the Nautical Almanac in the manner mentioned below, and subtracted from the moon's horary motion in longitude: the remainder will be the *horary motion of the moon from the sun* in longitude. Thus, on the 16th of June, 1806, the sun's horary motion was 2′ 23″.1, which, being subtracted from the horary motions found in Example II., 36′ 39″.2, and 36′ 42″.8, leaves the corresponding horary motions of the moon from the sun in longitude 34′ 16″.1, and 34′ 19″.7.

As the sun has no sensible motion in latitude, the relative horary motion of the moon from the sun in latitude, is the same as the true horary motion of the moon in latitude.

* The motion in 12 hours thus obtained, which, for distinction, will be called the arc M, is not perfectly accurate, since the third and higher orders of differences are neglected; but the horary motion deduced therefrom is abundantly sufficient for the purpose of projecting an eclipse or occultation. When greater accuracy is required, the third differences may be taken into account in the following manner:—Having found the *second differences* as above directed, subtract the first of them from the second, noting the signs as in algebra, and call the remainder the arc *b*. Enter Table XLV. with this arc at the top, and the time T at the side, and take out the corresponding correction, which is to be increased by one sixth part of the arc *b*, without noting the signs. To the quantity thus found is to be prefixed a sign *different from that of the arc b*, and then it is to be applied to the arc M, with its sign, to obtain the true motion in 12 hours. Thus, in the above example, the *second differences* of longitude are + 5′ 2″ + 4′ 47″. Subtracting the former from the latter, leaves the third difference or arc *b* = — 15″. Corresponding to this and the time T 3h. 48m 29s. in Table XLV., is 1″.6, which, increased by one sixth of *b* = 2″.5, gives the sought correction 4″.1 or 4″ to which must be prefixed the sign + (because the sign of *b* is negative), making it + 4″. This, connected with the arc M = + 7° 10′ 20′, gives the true motion in 12 hours, 7° 10′ 24″, whence the horary motion is 35′ 52″. In a similar manner, if the third differences were noticed in the above example for finding the horary motion in latitude, the two *second differences* — 2′ 24″ and — 1′ 49″, the arc *b* = + 35″, the correction of the motion in 12 hours — 36′ 32″ is — 10″; making it — 36′ 42″, or 3′ 3″.5 per hour.

Digitized by Google

3. The horary motions of the sun in longitude were formerly given in page iii of the Nautical Almanac; but they are discontinued in its new form, so that we must now deduce the horary motion from the daily difference of longitude, by dividing it by 24.

EXAMPLE III.

Thus, if it were required to find the sun's horary motion in longitude, in the interval between July 1 and July 2, 1836, mean time, astronomical account, at Greenwich; we should have the longitude at noon, July 1, 99° 35′ 03″.0; July 2, 100° 32′ 13″.7. Their difference is 57′ 10″.7; dividing it by 24, we get the sun's horary motion in longitude 2′ 22″.9.

The same method may be used in finding the horary motions of the planets, neglecting the second differences; but if we wish to notice the second differences, we may proceed as in the three preceding examples, making use of the arcs A, B, T, found as in *Remark* 2, Problem I.

EXAMPLE IV.

Required the horary motion of Venus in right ascension, 1836, August 23d. 16h. 40m., mean time, astronomical account, at Greenwich.

Here we have, as in Example V. of the preceding problem, T = 8h. 20m.; and the mean of the two first differences, 1m. 00s.54, and 1m. 08s.79, is the approximate motion, 1m. 04s.66; also the arch B = + 8s.13.................................. Prop. Log. 3.124
¼ T = 2h. 5m.................................. Prop. Log. 158

Correction 5s.66.... .... Prop. Log. 3.282

Approximate motion .... 1 04 .66

Motion of Venus in 24 hours.... 1m. 10s.32

Dividing it by 24, we get........ 2s.93, which represents the horary motion of Venus in right ascension, corresponding to August 23d. 16h. 40m.

The horary motion of the moon in right ascension or declination is found, by inspection, in the Nautical Almanac, taking the differences of the two successive numbers in the Nautical Almanac, the one before, the other after, the time for which the horary motion is wanted.

EXAMPLE V.

Required the horary motion of the moon in right ascension and declination, between the hours of 10 and 11, on the 4th of August, 1836, mean time, astronomical account, at Greenwich.

1836, August 4d. 10h.	Moon's right ascension	3h. 07m. 20s.15		Declination	17° 52′ 44″.2 N.
4 11		3 09 19 .57			18 03 30 .4
The differences are the horary motion.	In R. A.	1m. 59s.42		In declination	10′ 46″.2

These horary motions correspond very nearly to the middle of the time between 10h. and 11h., that is to say, 10h. 30m.

PROBLEM III.

To find the time of the ecliptic conjunction or opposition of the moon with the sun, a planet, or a fixed star.

The time of the ecliptic conjunction of the sun and moon is the same as the time of new moon given for the meridian of Greenwich in page xii. of the month of the Nautical Almanac. Thus, in January, 1836, the ecliptic conjunction is on the 17th day, at 20h. 27m.8 mean time, at Greenwich. The time of the ecliptic opposition of the sun and moon is the same as at the time of full moon given in the same page of the Nautical Almanac. Thus the full moon or ecliptic opposition in May, 1836, was 30d. 3h. 59m.7, at Greenwich.

The time of the ecliptic conjunction is easily computed from the geocentric longitudes of the objects; and we have here inserted the rule, adapted to the calculation of the conjunction of the sun and moon, which, with a slight modification, will answer for any planet, or a fixed star.

RULE.

Take from the Nautical Almanac the two longitudes of the sun and moon at the noon and midnight* preceding the time of the conjunction, and the two immediately following. Subtract the longitudes of the sun from those of the moon, noting the signs as in algebra; the remainders will represent the *distances* of the sun from the moon on the ecliptic. Subtract each of these from the following to obtain the *first differences*, and call the middle term the arch A; subtract each of these differences from the following for the *second differences*, and take their half sum or mean for the arc B, noting the signs as in algebra

To the constant logarithm 4.63548, add the arithmetical complement of the log. of the arca A in seconds, and the log. of the second of the above-found distances in seconds; the

* The sun's longitude at midnight is the mean of the longitudes on the preceding and following noons nearly

sum rejecting 10 in the index, will be the logarithm of the approximate value of T in seconds.

With this time T at the side of Table XLV., and the arc B at the top, find the equation of second differences, the logarithm of which, added to the two first logarithms used in finding T, will. in rejecting 10 in the index, give the logarithm of the correction of the approximate time T in seconds, to be applied to it with the *same sign as the arc B*, and the mean time of the conjunction at Greenwich, counted from the second noon or midnight, taken from the Nautical Almanac, will be obtained. From which the time of conjunction under any other meridian may be easily obtained, by adding to it the longitude in time when *east*, or subtracting when *west*.

Remark 1. When the time of the ecliptic conjunction of the moon and a planet is required, the longitudes of the planet must be found by Problem I. for the noon and midnight immediately preceding, and those immediately following the time of the conjunction, and these are to be used in the above note instead of the sun's longitudes. If the ecliptic conjunction of the moon with a fixed star is required, its longitude must be found in Table XXXVII., and corrected for the equation of the equinoxes and aberration by Tables XL. XLI., as shown in the explanation of those tables. This longitude is to be used instead of the sun's, in the above rule. The longitude and latitude of the star may also be computed more accurately, from the right ascension and declination, given in the Nautical Almanac, by the method in Problem XIX. of this Appendix, whenever the star used is one of the 100 stars, whose places are given for every 10 days in the Nautical Almanac.

Remark 2. By the same rule, the time, when the moon is at any distance from the sun, may be found, by increasing the sun's longitudes given in the Nautical Almanac, by the quantity the moon is supposed to be distant from the sun, counted according to the order of the signs; then supposing a *fictious* sun to move so as to have these increased longitudes at the corresponding times, and finding by the above rule the time of conjunction of the moon with this *fictious* sun, which will be the sought time when the moon is at the proposed distance from the sun. Thus, to find the time of the first, second, or third quarter of the moon, the sun's longitudes must be increased 3, 6, or 9 signs respectively (rejecting, as usual, 12 signs when the sun exceeds that quantity). Thus, if the first quarter of the moon which happened in the afternoon, July 21, 1836, was required: The sun's longitudes increased by 3 signs give the longitudes of the *fictious* sun, July 20d. 12h.; 21d. 0h.; 21d. 12h., and 22d. 0h. respectively, 208° 11′ 10″.0; 208° 39′ 48″.8; 209° 08′ 27″.7, and 209° 37′ 06″.7. The longitudes of the moon corresponding are 200° 22′ 15″.8; 207° 03′ 18″.4; 213° 49′ 32″.4, and 220° 41′ 13″.8. Hence the time of the conjunction of the moon with the *fictious* sun found by the above rule, was July 21d. 3h. 5m. at Greenwich, which is the time of the first quarter required. In a similar manner, by increasing the longitudes of a planet or a star, the time may be found when the moon is at any proposed distance from it.

EXAMPLE.

Required the mean time of the ecliptic conjunction of the sun and moon in January, 1836

1836, Jan.	☽ long. ° ′ ″	☉ long. ° ′ ″	Distances. ° ′ ″	1st difference. ° ′ ″	2d difference. ′ ″
17d. 0h.	284 41 25.1	— 296 28 53.5	— 11 47 28.4		
17 12	292 07 35.4	— 296 59 26.6	— 4 51 51.2	6 55 37.2	— 2 12.8
18 0	299 31 33.0	— 297 29 59.8	2 01 33.2	A = 6 53 24.4	— 3 16.9
18 12	306 52 13.2	— 298 00 32.5	8 51 40.7	6 50 07.5	B = — 2 44.8

Constant 4.63548	.... 4.63548
A = 6° 53′ 24″.4 = 24804″.4 Arith. Comp. Log. 5.60547	.... 5.60547
2d dis. 4 51 51 .2 = 17511 .2 ....Log. 4.24332	Table XLV. Corr. 17″.1.........Log. 1.23300
T 30498s. = 8h. 28m. 18s. ....Log. 4.48427	Correction 30s. ....Log. 1.47395
Correction — 30	

Conjunction 8h. 27m. 48s. past midnight, on January 17d. 20h. 27m. 48s., mean time at Greenwich; being the same as in the Nautical Almanac. The time of conjunction under any other meridian, as for example, 30° W., is found by subtracting the longitude 2h. from 20h. 27m. 48s., which leaves 18h. 27m. 48s. If the longitude had been 30° E., the time of conjunction would have been 22h. 27m. 48s.

The usual method of calculating the parallaxes in eclipses of the sun or occultations, is that by using the longitude and latitude of the *nonagesimal* or ninetieth degree of the ecliptic above the horizon; or, in other words, the longitude and complement of the latitude of the zenith, relative to the ecliptic. Several methods have been proposed for calculating the altitude and longitude of this point, which are required at each of the phases. The following, which is an improvement I have made on that given in La Lande's Astronomy, seems well adapted to the purpose, since several of the logarithms are the same at each of the phases, which much abridges the calculation, and on this account it admits of considerable simplifications, by a table like that on page 403. The method of making these calculations will first be given at full length, and then in the abridged form, by means of the proposed table. The process of calculating the parallaxes with the right ascensions and declinations, instead of the longitudes and latitudes of the bodies, adapted particularly to the new form of the Nautical Almanac will be given towards the end of this Appendix.

Digitized by Google

PROBLEM IV.

Given the apparent time at the place of observation, counted from noon to noon, according to the manner of astronomers, the sun's right ascension, and the latitude of the place reduced on account of the spheroidal figure of the earth, by subtracting the reduction of latitude, Table XXXVIII.; to find the altitude and longitude of the nonagesimal degree of the ecliptic.

RULE NOT ABRIDGED.

Add 6 hours to the sum of the sun's right ascension and the *apparent time of observation*, and call the sum the time T, rejecting 24 hours when it exceeds that quantity. Seek for this time in the column of hours of Table XXVII., supposing that marked A. M. to be increased by 12 hours, as in the astronomical computation. The corresponding log. cotangent being found, is to be marked in the first and second columns, as in the following examples.

If the reduced latitude is *north*, subtract it from 90°; if *south*, add it to 90°; the sum or difference will be the polar distance. Take half of this, and half the obliquity of the ecliptic, and find their *difference* and *sum*. Place the log. cosine of the difference in the first column its log. sine in the second column; the log. secant of the *sum* in the first column, its log cosecant in the second column, and its log. tangent in the third.

The sum of the logarithms in the first column, rejecting 20 in the index, will be the log. tangent of the arc G; the sum of these in the second column, rejecting 20 in the index, will be the log. tangent of the arc F; these arches being *less* than 90° when the time T is found in the column A. M., otherwise *greater*. This rule is general except in places situated within the polar circles. Within the *north* polar circle, the supplement of F to 360° instead of F, must be taken; within the *south* polar circle, the supplement of G to 180° must be taken instead of G; the other terms remaining unaltered. In all cases, the longitude of the nonagesimal is equal to the sum of the arcs F, G, thus found, and 90°; rejecting 360° when the sum exceeds that quantity.

Place in the third column the log. cosine of G, and the log. secant of F; the sum of the three logarithms of this column, rejecting 20 in the index, will be the log. tangent of half the altitude of the nonagesimal.

EXAMPLE.

Required the altitude and longitude of the nonagesimal at Salem, in the reduced latitude 42° 22′ 4″ N., June 15, 1806, at 22h. 6m. 18s.1, apparent time, or 22h. 6m. 21s.5, mean time, by astronomical computation, when, by the Nautical Almanac, the sun's right ascension was 5h. 36m. 50s., and the obliquity of the ecliptic 23° 27′ 48″.

The sum of the *apparent time*, sun's right ascension, and 6 hours, rejecting 24 hours, is 9h. 43m. 8s.1 = T. The polar distance is 47° 37′ 56″; its half is 23° 48′ 58″, and the half obliquity 11° 43′ 54″; hence their difference is 12° 5′ 4″, their sum 35° 32′ 52″. The rest of the calculation is as follows:—

Column 1.			Column 2.		Column 3.		
Diff. 12° 5′ 4″	.........Cosine	9.99027	Sine	9.32088			
Sum 35 32 52	.........Secant	10.08957	Cosecant	10.23554		Tangent	9.85403
T 9h. 43m. 8s.1 P. M.	.........Cotang	9.48826		9.48826	G.	Cosine	9.97215
					F.	Secant	10.00265
G. 159° 42′ 0″	Tang	9.56810	F Tang	9.04468	33° 59′ 25″	Tang.	9.82883
F 173 40 31							
90					67 58 50 = Alt. nonagesimal.		
Sum 63 22 31, rejecting 360°, is the longitude of the nonagesimal.							

The two upper logarithms of the first and second columns, and the upper logarithm of the third column, vary but little in several centuries; and as these numbers occur twice in calculating a partial eclipse or occultation, and four times in a total or annular eclipse or transit, it will tend considerably to abridge the calculations, to have a table like the following, containing their values for various places, for the obliquity 23° 27′ 40″, with the variations for an increase of 100″ in the latitude or obliquity. The logarithms A, B, C, of the table, were calculated in the following manner:—

In *north* latitudes subtract the reduced latitude from 90°, in *south* latitudes add the reduced latitude to 90°, the sum or difference will be the polar distance: take half of this and half of the obliquity of the ecliptic, 11° 43′ 50″, and find the *sum* and *difference*. Then,

Log. A is equal to the log. cosine of the *difference* added to the log. secant of the *sum*, rejecting 20 in the index.

Log. C is equal to the log. tangent of the sum.

Log. B is equal to the log. tangent of the difference, increasing the index by 10, less the log. C.

Thus, for Salem, in the reduced latitude 42° 22′ 4″, the half polar distance is 23° 48′ 58″ the half obliquity 11° 43′ 50″, the *difference* 12° 5′ 8″, the *sum* 35° 32′ 48″.

Difference	12° 5′ 8″	Cosine 9.99027	Tangent + 10 =	19.33065
Sum.....	35 32 48	Secant 10.08956	Tangent = C =	9.85402
Sum A.................		0.07983	Difference B....	9.47663

Digitized by Google

In this way the logarithms may be found for places not included in the table. The changes for an increase of 100′′ in the latitude or obliquity, are found by repeating the operation with these increased values, and ascertaining the corresponding changes in the values of A, B, C. These logarithms are given to six places of figures, though, in general, five will be quite sufficient, since the latitude and longitude of the nonagesimal are rarely required to a greater degree of accuracy than 10′′.

TABLE, calculated for the obliquity 23° 27′ 40′′.

Places.	Reduced Latitude North.			A.	Var. A. + 100′′.		B.	Var. B. + 100′′.		C.	Var. C. + 100′′.	
					Lat.	Obl.		Lat.	Obl.		Lat.	Obl.
	°	′	′′		−	+		−	−		−	+
Albany, ...	42	27	13	0.079670	53	97	9.475733	293	739	9.853328	223	223
Berlin, ...	52	20	24	0.061608	49	75	9.324135	618	1099	9.771197	240	240
Cambridge, E....	52	1	28	0.062166	49	76	9.331054	600	1080	9.773925	240	210
Cambridge, A....	42	12	2	0.080150	52	97	9.478383	288	733	9.855355	222	222
Dublin Obs.	53	12	7	0.060090	48	73	9.304166	670	1155	9.763705	242	242
Edinburgh, ...	55	46	2	0.055618	47	67	9.233401	878	1376	9.741011	249	219
Greenwich Obs...	51	17	28	0.063466	49	77	9.340396	562	1038	9.780232	238	238
Havanna, ...	23	3	34	0.120000	64	148	9.597658	95	516	10.003045	210	210
Kinderhook, ...	42	11	37	0.080163	52	98	9.478455	289	733	9.855411	222	222
Lancaster, ...	39	51	18	0.084648	54	104	9.501042	249	688	9.874005	219	219
Leon I. Obs......	36	16	52	0.091680	55	112	9.529940	202	634	9.902005	216	216
London, ...	51	19	29	0.063406	49	77	9.345714	564	1040	9.779944	238	238
Natchez, ...	31	17	36	0.101899	58	125	9.561510	152	577	9.940447	212	212
Oxford Obs.......	51	34	28	0.062963	50	77	9.340586	576	1054	9.777800	239	239
Paris, ...	48	38	51	0.068207	50	83	9.394413	452	918	9.802627	233	233
Philadelphia, ...	39	45	44	0.084828	53	104	9.501872	248	687	9.874738	219	219
Richmond Obs. ..	51	16	56	0.063482	49	78	9.346576	562	1038	9.780308	238	238
Rutland, ...	43	24	32	0.077866	52	95	9.465330	312	760	9.845648	224	224
Salem, ...	42	22	4	0.079832	52	98	9.476637	291	731	9.854016	222	222
Place Prob. VII..	19	52	38	0.127485	66	157	9.607602	78	500	10.027183	211	211

These logarithms are calculated for the obliquity 23° 27′ 40′′. The columns marked *Lat.* represent the variations of A, B, C, for an increase of 100′′ in the reduced lat. The column *Obl.* represents the variations of A, B, C, for an increase of 100′′ in the obliquity of the ecliptic. The signs must be changed if the latitude or obliquity is less than 23° 27′ 40′′, which is used in calculating the table.

EXAMPLE.

Required the values of A, B, C, for Salem, when the obliquity is 23° 27′ 48′′.

Tabular numbers	0.079832	9.476637	9.854016
Variation for + 8 obliquity.........	+ 8	− 58	+ 18
Sought values.....	A = 0.079840	B = 9.476579	C = 9.854034

Abridged method of calculating the altitude and longitude of the nonagesimal by the preceding table.

Add together the sun's right ascension, the apparent time at the place of observation, (counted from noon to noon), and 6 hours: the sum, rejecting 24 or 48 hours if greater than those quantities, is to be called the time T: this is to be sought for in the column of hours of Table XXVII., supposing the column marked A. M. to be increased 12 hours, as in the astronomical computation.* The corresponding log. cotangent, added to the log. A of the table, gives the log. tangent of the arc G: this added to the log. B of the table, rejecting 10 in the index, will be the log. tangent of the arc F; these arcs being *less* than 90° when T is found in the column A. M., otherwise *greater*.† [This rule is general, except in places situated within the polar circles, which is a case that very rarely occurs. Within the *north* polar circle, the supplement of F to 360° is to be used instead of F; within the *south* polar circle, the supplement of G to 180° is to be taken instead of G; the other terms remaining unaltered.] Then the *longitude of the nonagesimal* is equal to the sum of the arcs F, G, and 90°, neglecting as usual 360° when the sum exceeds that quantity.

To the tabular log. C, add the log. cosine of the arc G, and the log. secant of the arc F: the sum, rejecting 20 in the index, will be the log. tangent of half the altitude of the nonagesimal.‡

* Thus, if the time T is 5 hours, it must be called 5h. P. M.; if T is 14 hours, it must be called 2h. A. M. In making use of a common table of logarithms, you must turn the time T into degrees, and make use of the log cotangent of its half. To prevent mistake, it may be proper to remark, that, in finding T, we must add the *apparent* time, and not the *mean* time; for if the *mean* time be used, we ought to use also the *mean* right ascension; whereas the *apparent* right ascension is given in the Nautical Almanac; and this must be added to the *apparent* time in finding T.

† The arcs F, G, are *acute*, when the time T is found in the column A. M., otherwise *obtuse*. This is easily remembered from the circumstance that *a* is the first letter of *acute* and A. M. Some writers have not taken notice of the cases of the values of F, G, within the polar circles.

‡ Strictly speaking, the quantity thus obtained is the distance between the north pole of the ecliptic and the zenith of the place, which, in southern latitudes, and between the tropics, is frequently the supplement to the altitude of the nonagesimal. The above form is made use of to simplify the rules for applying the

Digitized by Google

EXAMPLE I.

Required the altitudes and longitudes of the nonagesimal at Salem, June 16, 1806, at the times of the beginning and end of the eclipse, calculated in Problem VI.

BEGINNING OF THE ECLIPSE.

	h. m. s.			
	5 36 50.0	⊙ right ascension.		
	22 6 18.1	*Apparent* time.		
	6	A 0.07984		
T	9 43 8.1	Cotang. 9.48826		
G	159° 42′ 0″	Tang. 9.56810	Cosine	9.97215
	90	B 9.47658	C	9.85403
F	173 40 31	Tang. 9.04468	Secant	10.00265
	63 22 31 = long. N.	33 59 25	Tang.	9.82883

Altitude nonagesimal.. 67 58 50

END OF THE ECLIPSE.

	h. m. s.			
	5 37 18.5	⊙ right ascension.		
	0 50 34.6	*Apparent* time.		
	6	A 0.07984		
T	12 27 53.1	Cotang. 8.78470		
G	4° 11′ 13″	Tang. 8.86454	Cosine	9.99884
	90	B 9.47658	C	9.85403
F	1 15 23	Tang. 8.34112	Secant	10.00016
	95 26 36 = long. N.	35 28 53	Tang.	9.85297

Altitude nonagesimal.. 70 57 46

EXAMPLE II.

Required the altitudes and longitudes of the nonagesimal at the times and places mentioned in the Example of Problem VII.

IMMERSION.

	h. m. s.			
	17 20 59	⊙ right ascension.		
	16 57 29	*Apparent* time.		
	6	A 0.12748		
T	16 18 28	Cotang. 9.80098		
G	40° 18′ 7″	Tang. 9.92846	Cosine	9.88233
	90	B 9.60760	C	10.02718
F	18 57 48	Tang. 9.53606	Secant	10.02423
	149 15 55 = long. N.	40 38 46	Tang.	9.93374

Altitude nonagesimal.. 81 17 32

EMERSION.

	h. m. s.			
	17 21 12.5	⊙ right ascension.		
	18 10 29	*Apparent* time.		
	6	A 0.12748		
T	17 31 41.5	Cotang. 9.94622		
G	49° 50′ 18″	Tang. 10.07370	Cosine	9.80953
	90	B 9.60760	C	10.02718
F	25 38 40	Tang. 9.68130	Secant	10.04504
	165 28 58 = long. N.	37 17 39	Tang.	9.88125

Altitude nonagesimal.. 74 35 18

In these calculations, it is usual to take the sun's right ascension, and the apparent times to tenths of a second, and to take proportional parts for the seconds and tenths in finding the logarithms. Thus, in Example I., in finding the log. cotangent of 9h. 43m. 8s.1, the nearest logarithms are 9.48849, 9.48804, corresponding to the times 9h. 43m. 4s., 9h. 43m. 12s. These logarithms differ 45, the times 8s.; and the difference between 9h. 43m. 4s., and 9h. 43m. 8s.1, is 4s.1. Hence, 8s. : 45 .. 4s.1 : 23, the correction to be subtracted from the first log. 9.48849 (because it is decreasing), to obtain the sought log. cotangent 9.48826.

PROBLEM V.

Given the altitude and longitude of the nonagesimal; the longitude, latitude, and horizontal parallax of the moon, and the latitude of the place of observation; to find the moon's parallax in latitude and longitude.

RULE BY COMMON LOGARITHMS.

From the horizontal parallax of the moon, subtract its correction from Table XXXVIII., corresponding to the latitude of the place; the remainder, in occultations of a fixed star will be the *reduced* parallax; but in solar eclipses, this quantity is to be diminished by the sun's horizontal parallax, 8″.6,* to obtain the *reduced* parallax.

To the logarithm of the reduced parallax in seconds, add the log. sine of the altitude of the nonagesimal, and the log. secant of the moon's *true* latitude; † the sum, rejecting 20 in the index, will be a constant log. From the moon's true longitude,† increased by 360° if necessary, subtract the longitude of the nonagesimal; the remainder will be the *moon's distance from the nonagesimal*, which, if less than 180°, is to be called the arc D, otherwise its supplement to 360° is to be called the arc D. To the constant logarithm add the log. sine of D; the sum, rejecting 10 in the index, will be the logarithm of the *approximate* parallax in longitude in seconds, which add to the arc D; then take the log. sine of the sum, and add it to the constant logarithm, rejecting 10 in the index, and the logarithm of the *corrected* parallax will be obtained. This will, in general, be sufficiently exact; but when great accuracy is required, the operation may be again repeated, by adding the arc D to the *corrected* parallax; ‡ then to the log. sine of the sum add the constant logarithm, rejecting 10 in the index, and the logarithm of the *parallax in longitude* P will be obtained. This is

parallaxes. It is immaterial whether the altitude of the nonagesimal, or its supplement, is made use of in Table XLIV.

* This is nearly the mean value of the sun's parallax; but it will be more accurate to use the actual value as it is given in page 266 of the Nautical Almanac.

† Corrected for the errors of the tables, when known.

‡ This sum D + cor. par. is nearly equal to D + P, the apparent distance of the moon from the nonagesimal to be made use of in Table XLIV., in finding the augmentation of the moon's S. D.

Digitized by Google

to be *added* to the *true* longitude of the moon when her distance from the nonagesimal is *less* than 180°, otherwise *subtracted* to obtain her *apparent longitude*.

If the true latitude of the moon is *south*, prefix the sign + to it; if *north*, the sign —. Then to the logarithm of the reduced parallax in seconds, add the log. cosine of the altitude of the nonagesimal, and the log. cosine of the moon's apparent latitude;* the sum, rejecting 20 in the index, will be the logarithm of the *first part* of the parallax in latitude in seconds, to which prefix the sign + when the altitude of the nonagesimal is less than 90°, otherwise the sign —; this being added to the true latitude of the moon, due regard being paid to the signs, will give her *approximate* latitude.

To the logarithm of the reduced parallax in seconds, add the log. sine of the altitude of the nonagesimal, the log. sine of the moon's approximate latitude, and the log. cosine of the sum of the arcs D and ½ P; the sum, rejecting 30 in the index, will be the logarithm of the *second part* of the parallax in latitude in seconds, to which prefix the sign — when the arcs D + ½ P, and the approximate polar distance,† are both greater or both less than 90°, otherwise the sign +; this term, being connected with the approximate latitude, will give the *apparent latitude* of the moon,‡ which will be south if +, north if —. The moon's *true* latitude subtracted from her *apparent* latitude, noticing the signs, will give the *parallax in latitude*.

BY PROPORTIONAL LOGARITHMS.

The above rule will answer in calculating by proportional logarithms, with the following alterations. When the log. *sine* occurs, read log. cosecant; for log. *cosine*, read log. secant; for log. *secant*, read log. cosine; and for log. *cosecant*, read log. sine. The parallaxes may be calculated to the nearest second by proportional logarithms. When greater accuracy is required, common logarithms must be made use of.

To illustrate this rule, the following examples, corresponding to the times of the beginning and end of the total eclipse of the sun, of June 16, 1806, as observed at Salem, are given. The elements necessary for this purpose have already been calculated in Problems I. and IV. For greater accuracy, the longitudes and latitudes of the moon are corrected for the errors — 58″.5 in longitude, and — 11″.4 in latitude, which were found by comparing several observations of the eclipse made at different places.

EXAMPLE I.

Given the altitude of the nonagesimal 67° 58′ 50″, its longitude 63° 22′ 31″; the longitude of the moon 83° 49′ 3″.5, her latitude 24′ 27″.4 N., her horizontal parallax 60′ 24″.1; the latitude of the place of observation 42° 33′ 30″; required the parallaxes in longitude and latitude.

The correction in Table XXXVIII. corresponding to the latitude 42° 33′ 30″, and parallax 60′ 24″.1, is 5″.6; this, and the sun's horizontal parallax, 8″.8, subtracted from the moon's horizontal parallax, 60′ 24″.1, leaves the *reduced* parallax 60′ 9″.7 = 3609″.7. The longitude of the nonagesimal, 63° 22′ 31″, subtracted from the moon's longitude, 83° 49′ 3″, leaves the *moon's distance from the nonagesimal*, 20° 26′ 32″, equal to the arc D, because it is less than 180°.

CALCULATION BY COMMON LOGARITHMS.

Reduced parallax	3609″.7	Log.	3.55747
Altitude nonagesimal	67 58 50	Sine	9.96710
☽'s true latitude	24 27.4	Sec.	10.00001
Constant log.			3.52458
D	20 26 32	Sine	9.54315
Appr. parallax	1169″ = 19 29	Log.	3.06773
D + Appr. parallax	20 46 1	Sine	9.54970
Constant log.			3.52458
Cor. parallax	= 1187″ = 19 47	Log.	3.07428
D + cor. parallax	20 46 19	Sine	9.54980
Constant log.			3.52458
Par. long.	P 1186″.8 = 19 46.8	Log.	3.07438
☽'s true longitude	83 49 3.5		
☽'s app. longitude	84 8 50.3		

Reduced parallax	3609″.7	Log.	3.55747
Altitude nonagesimal	67 58 50	Cosine	9.57394
☽'s app. latitude		Cosine	10.00000
1 part paral. 1353″.3	= + 22′ 33″.3	Log.	3.13141
☽'s true latitude	— 24 27 .4		
☽'s approx. latitude	— 1 54 .1	Sine	6.743
Reduced parallax		Log.	3.557
Altitude nonagesimal		Sine	9.967
D + ½ P	20 36 25	Cosine	9.971
2 part parallax	— 1 .7	Log.	0.238
Approx. latitude	— 1 54 .1		
☽'s app. latitude	— 1 55 8	or	1′ 55″.8 N.

The sun's parallax formerly used as above, is 8″.8; it will be more accurate to use 8″.6, as in the rule.

* In *solar eclipses*, the apparent latitude is so small that its log. cos. may be put equal to 10.00000. In *occultations*, you must calculate the first part of the parallax in altitude by approximation, making use of the *true* latitude instead of the *apparent* in the above rule, and deducing the *approximate* value of the *first part* of the parallax; this applied to the *true* latitude will give the *approximate* apparent latitude, with which the operation is to be repeated, and the first part of the parallax will be obtained to a sufficient degree of exactness.

† The apparent polar distance is found by adding + 90° to the approximate latitude, due regard being had to the signs. To be perfectly accurate, the *apparent* instead of the *approximate* latitude ought to be made use of in this part of the calculation, and the logarithms of this term ought to be increased by the log. secant less radius of ½ P; but these corrections are too small to affect the result. In calculating the second part of the parallax in latitude, it will be sufficient to take the logarithm to three or four places of the decimals.

This rule gives the apparent latitude in all cases; but it may not be amiss to observe, that, in several late publications, the cases where the moon is between the zenith and the elevated pole are by mistake neglected

Digitized by Google

EXAMPLE II.

Given the altitude of the nonagesimal 70° 57′ 46″, its longitude 95° 26′ 30″; the longitude of the moon 85° 29′ 32″.6, her latitude 15′ 10″.4 N., her horizontal parallax 60′ 27″.0; the latitude of the place of observation 42° 33′ 30″; required the parallaxes in longitude and latitude.

The correction in Table XXXVIII., corresponding to the latitude 42° 33′ 30″, and parallax 60′ 27″, is 5″.6; this, and the sun's horizontal parallax, 8″.8, subtracted from the moon's horizontal parallax, 60′ 27″.0, leaves the *reduced* parallax 60′ 12″.6. The longitude of the nonagesimal, 95° 26′ 30″, subtracted from the moon's longitude increased by 360°, viz. 445° 29′ 33″, leaves the *moon's distance from the nonagesimal* 350° 2′ 57″, the supplement of which to 360° is 9° 57′ 3″, equal to the arch D.

BY PROPORTIONAL LOGARITHMS.

Reduced parallax		60′	12″.6	Prop. Log.	0.4756
Altitude nonages	70	57	46	Cosecant	10.0244
☽'s true latitude		15	10 .4	Cosine	10.0000
Constant log.					0.5000
D	9	57	3	Cosecant	10.7624
Approx. parallax		9	50	Prop. Log.	1.2624
D + appr. parallax	10	6	53	Cosecant	10.7554
Constant log.					0.5000
Corrected parallax		10	0	Prop. Log.	1.2554
D + cor. parallax	10	7	3	Cosecant	10.7553
Constant log.					0.5000
Par. long. P		10	00	Prop. Log.	1.2553
☽'s true longitude	85	29	32 .6		
☽'s app. longitude	85	19	32 .6		

Reduced parallax		60′	12″.6	Prop. Log.	0.4756
Altitude nonages.	70	57	46	Secant	10.4865
☽'s app. latitude				Secant	10.0000
1 part par. lat.	+	19	38 .5	Prop. Log.	0.9621
☽'s true latitude	—	15	10 .4		
☽'s approx. lat.	+	4	28 .1	Cosecant	12.8861
Reduced par.				Prop. Log.	0.4756
Altitude nonages.				Cosecant	10.0244
D + ½ P	10	2	3	Secant	10.0067
2 part par. lat.	+		4 .4	Prop. Log.	3.3928
Approx. latitude	+	4	28 .1		
Apparent lat.	+	4	32 .5	or	4′ 32″.5 S.

EXAMPLE III.

Required the parallaxes in longitude and latitude at the time of the occultation of Spica December 12, 1808, at the times and places mentioned in the Example of Problem VII.

IMMERSION.

Reduced parallax		59′	50″.9	Prop. Log.	0.4782
Alt. nonagesimal	81	17	32	Cosecant	10.0050
☽'s true latitude	1	55	11	Cosine	9.9998
Constant log.					4830
D	50	52	1	Cosecant	10.1103
Approx. parallax		45	55	Prop. Log.	5933
D + appr. parallax	51	37	56	Cosecant	10.1057
Constant log.					4830
Corrected parallax		46	25	Prop. Log.	5887
D + cor. parallax	51	38	26	Cosecant	10.1056
Constant log.					4830
Par. long. P	+	46	25	Prop. Log.	5886
☽'s true longitude	200	7	56 .3		
☽'s app. long.	200	54	21 .3		

....					0.4782
....				Secant	10.8199
☽'s app. latitude*				Secant	10.0003
1 part par. lat.	+		9′ 3″.3	Prop. Log.	1.2984
☽'s true lat.	+ 1	55	11 .0		
☽'s approx. lat.	+ 2	4	14 .3	Cosecant	11.4421
Reduced parallax				Prop. Log.	0.4782
Alt. nonagesimal				Cosecant	10.0050
D + ½ P	51	15	13	Secant	10.2035
2 part par. lat.	+	1	20 .3	Prop. Log.	2.1285
☽'s approx. lat.	+ 2	4	14 .3		
☽'s app. lat.	+ 2	5	34 .6	South.	
☽'s par. latitude	+	10	23 .6		

EMERSION.

Reduced parallax		59′	53 .0	Prop. Log.	0.4780
Alt. nonagesimal	74	35	18	Cosecant	10.0159
☽'s true latitude	1	51	29 .1	Cosine	9.9998
Constant log.					0.4937
D	35	22	38	Cosecant	10.2374
Appr. parallax		33	26	Prop. Log.	7311
D + appr. par.	35	56	4	Cosecant	10.2315
Constant log.					4937
Corrected parallax		33	54	Prop. Log.	7252
D + corr. par.	35	56	32	Cosecant	10.2314
Constant log.					4937
Par. long. P	+	33	54	Prop. Log.	7251
☽'s true long.	200	51	36 .1		
☽'s app. long.	201	25	30 .1		

....					0.4780
....				Secant	10.5755
☽'s approx. latitude				Secant	10.0005
1 part par. lat.	+		15′ 54″.2	Prop. Log.	1.0538
☽'s true lat.	+ 1	51	29 .1		
☽'s approx. lat.	+ 2	7	23 .3	Cosecant	11.4313
Reduced parallax				Prop. Log.	0.4780
Alt. nonagesimal				Cosecant	10.0159
D + ½ P	35	39	35	Secant	10.0902
2 part par. lat.	+	1	44 .2	Prop. Log.	2.0154
☽'s approx. lat.	+ 2	7	23 .3		
☽'s appar. lat.	+ 2	9	7 .5	South.	
☽'s parallax lat.	+	17	38 .4		

* The moon's true latitude, 1° 55′ 11″, must first be used, its log. secant being 10.0002, which give the 1st part parallax 9′ 3″, which added to the true latitude of the moon, gives the approximate latitude nearly 2° 4′ 14″, the log. secant which is 10.0003, as above. The calculation for the emersion is made in a similar manner

Digitized by Google

Having thus explained the method of calculating the parallaxes of the moon, it now remains to give the rules for finding the longitude by eclipses and occultations. The main object in these calculations is to determine, from the observed beginning or end of the eclipse or occultation, the precise time of the ecliptic conjunction of the sun, or star and moon, free from the effects of parallax, counted on the meridian of the place of observation, since the difference of the times of conjunction, obtained in this manner at two places, will be their difference of longitude. If the lunar and solar tables were perfectly correct, the longitude might be determined by taking the difference between the time of conjunction given in the Nautical Almanac, and that deduced from the observations of the eclipse or occultation; but it is much more accurate to compare the times deduced from observations actually made at the places for which the difference of longitude is sought. There are two different methods of finding the ecliptic conjunction, according as the latitude of the moon is supposed to be accurately known or not. If the latitude was given correctly by the lunar tables, or was accurately known by other observations, the ecliptic conjunction, and the longitude of the place, might be determined by each of the phases of the eclipse or occultation, by the method given in Problems VIII. and IX. But the moon's latitude not being generally given to a sufficient degree of accuracy, it is usual to combine together the observations of the beginning and end of the eclipse or occultation, or the beginning and end of total darkness in a total eclipse, or the two internal contacts of an annular eclipse, to ascertain the error of the moon's latitude, by the method given in Problems VI. and VII. In making the calculations in these Problems, it will be necessary to know nearly the longitude of the place, in order to find the supposed time at Greenwich, so as to take out the elements from the Nautical Almanac; and if the longitude deduced from the observation should differ considerably, the operation must be repeated with the longitude obtained by this operation.

PROBLEM VI.

Given the latitude of the place, and the apparent times of the beginning and end of a solar eclipse, counted from noon to noon, according to the method of astronomers, to find the longitude of the place of observation.

In the rule for solving this problem, references will be made to figure 12, Plate XIV, in which DSE represents a small arc of the ecliptic; S, the place of the centre of the sun, supposed at rest; F, L, the apparent places of the centre of the moon at the beginning and end of the eclipse respectively; FD, SC, and AEL, are perpendicular to DE; FA parallel to DE, and SB perpendicular to FL. Then it is evident that FD, LE, represent the apparent latitudes of the moon, which fall below DE if *south*, above if *north*; and SF, SL, represent the sums of the corrected semi diameters of the sun and moon, at the beginning and end of the eclipse respectively.

RULE.*

To the apparent times of the beginning and end of the eclipse, add the estimated longitude of the place in time if it is *west*, but subtract if *east*; the sum or difference will be the supposed time at Greenwich, corresponding to which, in the Nautical Almanac, find, by Problem I., the moon's semi-diameter, horizontal parallax, longitude and latitude,† and the sun's semi-diameter, longitude, and right ascension; also the moon's horary motion from the sun, by Problem II. Decrease the sun's semi-diameter $3\frac{1}{2}''$ for irradiation, and the remainder will be his *corrected* semi-diameter. Decrease the moon's semi-diameter $2''$ for inflexion, if it be thought necessary, and to the remainder add the correction in Table XLIV.;‡ the sum will be the moon's *corrected* semi-diameter. Find also, in the Nautical Almanac, the obliquity of the ecliptic.

With these elements, and the apparent time at the place of observation, calculate the altitudes and longitudes of the nonagesimal, by Problem IV.; the parallaxes in longitude and latitude, and the moon's apparent longitudes and latitudes, by Problem V.

Take the difference between the *apparent* longitudes of the moon at the beginning and end of the eclipse, and subtract therefrom the difference of the sun's longitudes at the same time; the remainder will be the relative motion in longitude DE or FA. The relative motion in latitude AL is found by taking the difference of the moon's *apparent* latitudes at the beginning and end of the eclipse, if they are both north, or both south, but their sum, if one be north, the other south. From the logarithm FA, increasing the index by 10, subtract the logarithm of AL; the remainder will be the log. tangent of the *angle of inclination* DSB; this angle is to be taken *greater* than 90°, when the moon's apparent latitude FD, at the beginning of the eclipse, is *greater* than at the end EL, otherwise less.§ Then to the log.

* This rule is peculiarly adapted to the use of the longitudes and latitudes of the bodies. We shall hereafter give the methods of performing the same calculations by means of the right ascensions and declinations, adapting the rules to the new form of the Nautical Almanac. The same is to be observed relative to the following Problems, VII. VIII., &c.

† Corrected for the errors of the tables in longitude and latitude, when known.

‡ This correction must be found after the altitude and longitude of the nonagesimal are calculated.

§ This rule is equally true, whether the latitude be of the same or different names. If the latitudes are equal, and of the same name, the angle DSB will be 90°. If they are equal, but of different names, the angle DSB may be taken acute or obtuse, since, in that case, the angle FSB is 90°. Strictly speaking, when the points F, L fall on different sides of the line DF, the angle DSB is *greater* or *less* than 90°, according as the

Digitized by Google

cosecant of the angle of inclination. add the logarithm of the relative motion in longitude FA; the sum, rejecting 10 in the index, will be the logarithm of the apparent motion of the moon FL on her relative orbit. Then, in the triangle SFL, the sides SF, SL, represent the sums of the *corrected* semi-diameters of the sun and moon at the beginning and end of the eclipse, and these, with the relative motion FL, are given to find the angle FSB (by Case VI Obl. Trig.) Thus, to the log. arith. comp. of FL, add the logarithm of the sum of SF and SL, and the logarithm of their difference; the sum, rejecting 10 in the index, will be the logarithm of the difference of the segments FB, BL; half of which, being added to and subtracted from half of FL, will give the two segments FB, BL; the greater segment being contiguous to the greater side, whether SF or SL. Then, from the logarithm of the segment FB, increasing the index by 10, subtract the logarithm of SF; the remainder will be the log. sine of the angle FSB,* which is always less than 90°; the difference between this and the angle of inclination DSB will be the *central angle* DSF.

To the log. cosine of the *central* angle, add the logarithm of the sum of the corrected semi-diameters at the beginning of the eclipse SF, rejecting 10 in the index; the sum will be the logarithm of SD, the apparent difference of longitude of the sun and moon at that time. This is to be subtracted from the longitude of the sun at the beginning of the eclipse, if the central angle is less than 90°, but added if greater than 90°; the sum or difference will be the moon's apparent longitude: to this must be added the moon's parallax in longitude, when her distance from the nonagesimal (found as in Problem V., by subtracting the longitude of the nonagesimal from the moon's longitude, borrowing 360° when necessary) is greater than 180°; otherwise the parallax must be *subtracted*; the sum or difference will be the moon's *true longitude* at the beginning of the eclipse.

Take the difference in seconds between the sun's and moon's *true* longitudes at the beginning of the eclipse, to the logarithm of which add the arith. comp. logarithm of the moon's horary motion from the sun † in seconds, and the constant logarithm 3.55630; the sum, rejecting 10 in the index, will be the logarithm of the time from the conjunction in seconds, which is to be added to the observed apparent time of the beginning of the eclipse, when the sun's longitude at that time is greater than the moon's *true* longitude, otherwise subtracted; the sum or difference will be the apparent time of the true ecliptic conjunction of the sun and moon at the place of observation. The difference between this and the time of conjunction at Greenwich, inferred from the Nautical Almanac by Problem III., will be the longitude of the place of observation. But if corresponding observations have been made at different places, it will be much more accurate to find the times of the conjunction at each place by the above rule; and the difference of these times will be the difference of meridians, if it does not differ much from the supposed difference of longitude. If there is considerable difference, the operation must be repeated, making use of the longitude found by this operation; and thus, by successive operations, the true longitude may be obtained.

The longitude of the place of observation being accurately known, the errors of the lunar tables in longitude and latitude may be easily found. For the difference between the moon's *true* longitude deduced by the above method from the observations, and the longitude found from the Nautical Almanac, will be the error of the tables in longitude. To find the error in latitude, add the log. sine of the central angle DSF to the logarithm of the sum of the corrected semi-diameters at the beginning of the eclipse SF; the sum, rejecting 10 in the index, will be the logarithm of the moon's apparent latitude FD at that time; which will be south, if the point F falls below D, otherwise north. Take the difference between this and the moon's apparent latitude, found by Problem V., if they are both north, or both south; but their sum, if one be north and the other south; and the error of the tables in latitude will be obtained.‡

REMARK.

The above rule will answer for deducing the longitude from the observed beginning and end of the internal contacts of a total or annular eclipse. The differences consist in reading

---

expression $\frac{FD}{SF}$ is *greater* or *less* than $\frac{EL}{SL}$; but, as the divisors SL and SF are nearly equal, they may be neglected (as in the above rule), except in a case which very rarely occurs, namely, when the difference of SL, SF, is greater than the difference of the two apparent latitudes EL, FD, in which case the rule in this note must be made use of; observing that the fractions $\frac{EL}{SL}$, $\frac{FD}{SF}$, represent the quotients of the moon's apparent latitudes divided by the sum of the semi-diameters of the sun and moon.

* When SF, SL, are equal, or their difference is so small that it may be neglected, the log. sine of the angle FSB may be obtained much more expeditiously by subtracting the logarithm of the sum of SF and SL from the logarithm of FL, increasing the index by 10. This method may almost always be made use of without much error. It is the rule adopted by Doctor Mackay in his treatise on longitude.

† When the horary motion varies, it must be taken to correspond to the middle time between the beginning of the eclipse and the conjunction or new moon.

‡ When the eclipse or occultation is nearly central, or (in other words) when FD, EL, are very small in comparison with SF, the latitude thus found cannot be depended on, as a small error in the times of observation will produce a considerable error in the latitude. Indeed, the case may occur, when FD, EL, are less than 30″, that it may be uncertain whether the points F, L, fall above or below the line DE, because the error of the lunar tables in latitude may sometimes be equal to 30″. In this case, the correct latitude of the moon may be found, (1.) By observations made at another place, where the eclipse or occultation was not so central; (2.) By the number of digits eclipsed, if it was a solar eclipse; (3.) By the difference of declinations of the moon and star, observed before and after the immersion or emersion; (4.) By the meridian altitude of the moon observed the same day, whence it may be found whether the moon was north or south of her place given by the tables

Digitized by Google

the rule, beginning and end of the internal contacts, instead of beginning and end of the eclipse, and taking SF, SL, equal to the differences of the corresponding semi-diameters, instead of their sums.

EXAMPLE.

At Salem, in the latitude of 42° 33′ 30″ N., longitude by estimation 4h. 43m. 32s. W from Greenwich, the beginning of the total eclipse of June, 1806, was observed at 15d. 22h. 6m. 18s.1, and the end at the 16d. 0h. 50m. 34s.6, apparent time, by astronomical computation. Required the longitude of the place of observation.

Most of the following elements are calculated in Problems I. II. IV. V.

ELEMENTS OF THE ECLIPSE		Beginning.		End.
		d. h. m. s.		d. h. m. s.
Apparent times of observation at Salem		15 22 6 18.1		16 0 50 34.6
Estimated longitude W. from Greenwich		4 43 32		4 43 32
Supposed apparent time at Greenwich		16 2 49 50.1		16 5 34 6.6
☉'s right ascension		5 36 50.0		5 37 18.5
Lat. of place 42° 33′ 30″ — Reduction in Table XXXVIII. 11′ 26″.		42° 22′ 4″		° ′ ″
Obliquity of the ecliptic		23 27 48		
☽'s long. by N. A. — Err. Table 58″.5 = True long. ☽ Prob. I.		83 49 3.5		85 29 32.6
Longitude of the nonagesimal, by Prob. IV		63 22 31		95 26 36
☽'s true long. — Long. nonagesimal = ☽'s dist. from nonagesimal		20 26 32		350 2 57
This distance, or its supplement, if greater than 180°, is arch D	D	20 26 32	D	9 57 3
Altitude of nonagesimal, Prob. IV		67 58 50		70 57 46
☽'s horizontal parallax, by Prob. I.		60 24.1		60 27.0
— ☉'s hor. par. 8″.8* — Correction Table XXXVIII. 5″.6		— 14.4		— 14.4
Reduced parallax		60 9.7		60 12.6
☽'s semi-diameter by N. A. — Inflexion 2″		16 25.7		16 26.4
Add correction Table XLIV		15.2		16 4
☽'s corrected semi-diameter		16 40.9		16 42.8
☉'s semi-diameter by N. A. 15′ 46″.1 — Irradiation 3″.5		15 42.6		15 42.6
Sum of the corrected semi-diameters	SF =	32 23.5	SL =	32 25.4
☽'s horary motion in longitude by Prob. II. Example II		36 39.2		36 42.8
☉'s horary motion		2 23.1		2 23.1
☽'s horary motion from the sun†		34 16.1		34 19.7
☽'s parallax in longitude P		19 46.8		10 0.0
☽'s apparent longitude — Error Table 58″.5 by Prob. V		84 8 50.3		85 19 32 6
☉'s longitude by Prob. I		84 41 3.4		84 47 35.5
Difference ☽'s *app. longitude* = ☽'s app. motion		....		1 10 42.3
Difference ☉'s *longitudes* = ☉'s app. motion		....		6 32.1
Difference of motions of ☉ ☽		....	FA	64 10.2
☽'s true lat. by N. A. Prob. I. — Error Table 11″.4		— 24 27.4		— 15 10.4
☽'s app. lat. corr. for error Table 11″.4 by Prob. V	FD = —	1 55.8	EL = +	4 32.5
☽'s *latitude at end — Latitude at beginning*		....	AL = +	6 28.3

As the apparent latitude at the beginning of the eclipse is north, and at the end south, the point F corresponding to this example falls above DE, the point L below it. The rest of the calculation is as follows:—

FA 64′ 10″.2 = 3850″.2	Log. 13.58548		3.58548
AL 6 28.3 = 388 .3	Log. 2.58917		
Inclination 84° 14′...	Tan. 10.99631	Cosecant	10.00220
Apparent motion FL.....	3869″.7	Log.	3.58768
Its arith. comp.............			6.41232
SF + SL = 64′ 48″.9......	3888″.9	Log.	3.58983
Diff. SF, SL..............	1 .9	Log.	0.27875
Diff. segments............	1 .91	Log.	0.28090
Its half..................	0 .95		
Half of FL...............	1934 .85		
Sum is great segment.....	1935 .8		
Diff. is lesser segment FB.	1933 .9	Log.	13.28644
SF 32′ 23″.5 = ...	1943 .5	Log.	3.28858
Angle FSB.......	84° 19′	Sine	9.99786
Inclination	84 14		
Diff. is central angle DSF.	0 5	Cosine	10.00000
SF.................		Log.	3.28858
SD = 32′ 23″ 5 = ...	1943″.5	Log.	3.28858

☉'s longitude............	84° 41′ 3″.4		
SD..................	— 32 23 .5		
☽'s app. longitude.......	84 8 39 .9	by obs.	
☽'s par. longitude.......	— 19 46 .8		
☽'s true longitude.......	83 48 53 .1		
☉'s longitude	84 41 3 .4	Const.	3.55630
Difference 3130″.3........	= 52 10 .3	Log.	3.49556
☽'s hor. mot. from ☉ 34′ 17″.1 = 2057″.1		A.C.	6.68675
	h. m. s.		
Time from conj.	1 31 18.1 = 5478″.1	Log.	3.73863
App. time obs.	15 22 6 18.1		
App. time conj.	15 23 37 36.2	at Salem.	
Conjunction	16 4 19	at Greenwich.	
Diff Merid.	4 41 23.8		
....		Sine	7 16270
....		Log.	3.28858
App. lat. FD = 2″.8..		Log.	0.45128

* The mean parallax formerly used was 8″.8: it is now found to be nearly 8″.6.

† This horary motion increases from 34′ 16″.1 to 34′ 19″.7, or 3″.6, during the eclipse 2h. 44m. 16s.5, which is 1″.32 per hour. Now the ecliptic conjunction, or time of new moon, at Greenwich, by the N. A., was 4h. 19m., or rather 4h. 20m. 47s., corresponding to 23h. 37m. 15s. at Salem, which is 1h. 30m. 57s. after the beginning of the eclipse; and the increase of the horary motion in half that time is 1″, which, added to 34′ 16″.1, gives the horary motion 34′ 17″.1, corresponding in the middle time between the beginning of the eclipse and the conjunction. This is used in calculating the correct time of conjunction. We may remark that, in the above calculations, we have used the *apparent times* of observation, to conform to the arrangement of the Nautical Almanac in 1806; but the present form of the Nautical Almanac, it will be convenient to use the *mean time*.

Digitized by Google

In finding the time of conjunction or new moon, at Greenwich, 4h. 19m., in the Nautical Almanac, the longitude of the moon was supposed to be given correctly by the tables. If the calculation be made by Problem III., after allowing for the error —58″.5, the result will be 4h. 20m. 47s., whence the difference of meridians = 4h. 43m. 10s.8, which differs so little from the assumed longitude, 4h. 43m. 32s., that it will not be necessary to repeat the operation. If the eclipse was observed at Greenwich, the time of conjunction ought to be determined thereby, in a similar manner to the above calculations; or by those of Problem VIII., if only one of the phases is observed: by this means the errors of the tables will be wholly avoided. If the eclipse was not observed at Greenwich, the observations at any other place whose longitude is known might be made use of, and thus the difference of meridians accurately obtained.

The moon's true longitude. deduced from the above observation, is 83° 48′ 53″.1; by the Nautical Almanac it is 83° 50′ 2″.0; the difference, —68″.9, would be the error of the tables by this observation, if the assumed longitude, 4h. 43′ 32″, and the solar tables, were correct. By repeating the operation with the assumed longitude, 4h. 43m. 10s.8, the error, 68″.9, would be reduced to nearly the estimated value, 58″.5.

The eclipse was so nearly central at Salem, that a variation of a minute in the moon's latitude would hardly alter the times or duration of the eclipse; so that the latitude could not be determined by the above observations to any considerable degree of accuracy. From this cause it happens that the apparent latitude at the beginning of the eclipse is by the above calculation 2″.8, instead of 1′ 55″.8, as found by allowing the error, 11″.4, deduced from other observations made where the eclipse was not so nearly central, and by the limits of the shadow of total darkness.

PROBLEM VII.

Given the latitude of the place, and the apparent times of the beginning and end of an occultation of a fixed star by the moon, to find the longitude of the place of observation.

In the following rule, reference will be made to figure 13, Plate XIV., in which DSE represents a parallel to the ecliptic passing through the place of the star S, SF, SL, the corrected semi-diameters of the moon at the beginning and end of the occultation; DF, EL, the differences between the apparent latitudes of the moon and the star, when of the same name, or their sums, when of different names; either of these lines falling *below* DE if the moon's apparent latitude is more southerly than that of the star, otherwise above.

RULE.

To the apparent times of the beginning and end of the occultation, add the estimated longitude of the place in time if it is *west*, but subtract if *east*: the sum or difference will be the supposed time at Greenwich; corresponding to which, in the Nautical Almanac, find, by Problem I., the moon's semi-diameter, horizontal parallax, longitude and latitude,* and the sun's right ascension; also the moon's horary motion by Problem II., and the true longitude and latitude of the fixed star, by Table XXXVII., corrected for aberration and equation of equinoxes by Tables XL., XLI. This may also be deduced from the right ascension and declination of the star, if it be given in the Nautical Almanac, by means of Problem XIX of this Appendix. Find, also, in the Nautical Almanac, the obliquity of the ecliptic. To the moon's semi-diameter, add the correction in Table XLIV.,† and from the sum subtract the inflexion, 2″, if it be thought necessary; the remainder will be her *corrected* semi-diameter. With these elements and the apparent times of the place of observation, calculate the altitudes and longitudes of the nonagesimal, by Problem IV., and the parallaxes in longitude and latitude, and the moon's apparent longitudes and latitudes, by Problem V.

Take the difference between the *apparent* longitudes of the moon at the beginning and end of the occultation, which will be the moon's *apparent* motion in longitude, the logarithm of which, in seconds, being added to the log. cosine of the *mean*‡ of the apparent latitudes of the moon at the beginning and end of the occultation, rejecting 10 in the index, will be the logarithm of the motion of the moon on the parallel FA. The relative motion in latitude AL is found by taking the difference of the moon's *apparent* latitudes at the beginning and end of the eclipse if they are both north or both south; but their sum if one be north and the other south. From the logarithm of FA, increasing the index by 10, subtract the logarithm of AL; the remainder will be the log. tangent of the *angle of inclination* DSB; this angle is to be taken *greater* than 90° when the difference of the moon's and star's apparent latitudes at the beginning of the occultation FD is *greater* than at the end EL, otherwise less.§ Then to the log. cosecant of the angle of inclination, add the logarithm of the relative motion FA; the sum, rejecting 10 in the index, will be the logarithm of the apparent motion of the moon in her orbit FL.

---

* Corrected for the errors of the tables in longitude and latitude, when known.

† This correction must be found after the altitude and longitude of the nonagesimal are calculated.

‡ The mean latitude is half the sum of the two latitudes, if they are of the same name, but their half difference, if of different names. In solar eclipses, the correction for the *mean* latitude of the moon is neglected as too small to be taken notice of, the distance FA being taken equal to the difference of longitude DB (fig. 12. Plate XIV.).

§ This rule is equally true, whether the points F, L, fall on the same or on different sides of the line DE. If DF, EL, are equal, and the points F, L, fall on the same side of DE, the angle DSB will be 90°. If they are equal, and those points fall on different sides of the line DE, the angle DSB may be taken acute or obtuse. In strictness, when the points F, L, fall on different sides of DE, the angle DSB is greater or less than 90° according as the quantity $\frac{FD}{SF}$ is greater or less than $\frac{EL}{SL}$.

Digitized by Google

Then in the triangle SFL, the sides SF, FL (representing the corrected semi-diameters of the moon at the immersion and emersion), and the relative motion FL, are given to find the angle FSB (by Case VI. Oblique Trig.). Thus: to the log. arith. comp. of FL, add the logarithm of the sum of SF and SL, and the logarithm of their difference: the sum, rejecting 10 in the index, will be the logarithm of the difference of the segments FB, BL; half of this, being added to, or subtracted from the half of FL, will give the two segments FB, BL; the greater segment being contiguous to the greater side, whether SF or SL. Then, from the logarithm of the segment FB, increasing its index by 10, subtract the logarithm of SF; the remainder will be the log. sine of the angle FSB,* which is always less than 90°. The *difference* between this and the angle of inclination DSB, will be the *central angle* DSF.

To the log. cosine of the central angle add the logarithm of the moon's *corrected* semi-diameter at the immersion SF, and the log. secant of the star's latitude: the sum, rejecting 20 in the index, will be the logarithm of the apparent difference of longitude of the moon and star at that time. This is to be *subtracted* from the true longitude of the star, if the central angle is less than 90°, but added, if greater than 90°: the sum or difference will be the moon's *apparent* longitude; to this must be *added* the moon's parallax in longitude. when her distance from the nonagesimal (found as in Problem V., by subtracting the longitude of the nonagesimal from the moon's longitude, borrowing 360° when necessary) is *greater* than 180°, otherwise the parallax must be *subtracted;* the sum or difference will be the moon's *true longitude* at the beginning of the occultation.

Take the difference in seconds between the true longitudes of the star and moon at the beginning of the occultation; to the logarithm of this add the arithmetical comp. log. of the moon's horary motion † in seconds, and the constant logarithm 3.55630. the sum, rejecting 10 in the index, will be the logarithm of the time from the conjunction in seconds, which is to be *added* to the observed apparent time of the beginning of the occultation, when the star's longitude is greater than the moon's true longitude at that time, otherwise *subtracted:* the sum, or difference, will be the apparent time of the true ecliptic conjunction of the star and moon at the place of observation; the difference between this and the time of conjunction, inferred from the Nautical Almanac by Problem III. for the meridian of Greenwich, will be the longitude of the place. If corresponding observations be made at different places, it will be much more accurate to deduce from them the time of conjunction at each place, and take the difference of those times for the difference of meridians, if it does not differ much from the supposed difference of longitude. If there is considerable difference, the operation must be repeated, making use of the longitude found by this operation; and thus, by successive operations, the true longitude may be obtained.

The longitude of the place of observation being accurately known, the errors of the lunar tables in latitude and longitude may be easily found. For the difference between the moon's *true* longitude, deduced from the observations by the above method, and the longitude found from the Nautical Almanac, will be the error of the tables in longitude. To find the error in latitude, proceed thus: To the log. sine of the *central* angle DSF add the logarithm of the corrected semi-diameter of the moon at the immersion SF; the sum, rejecting 10 in the index, will be the logarithm of the apparent difference of latitude of the moon and star, which being added to the true latitude of the star, with the sign + if the point F falls *below* the line DE, but with the sign — if *above*, will give the apparent latitude of the moon at that time: the difference between this and the apparent latitude, found by Problem V., will be the error of the tables, always supposing the sign + to be prefixed to *southern* latitudes, the sign — to *northern*, and noting the signs as in algebra.‡

REMARK.

In the two preceding problems, the time of the true conjunction is calculated by means of the triangle SFD; but it will be useful, for the purpose of verification, to go over the calculation by means of the triangle SLE. The process is nearly the same in both methods. The differences consist in finding the angle LSB, by subtracting the logarithm of SL from the logarithm of LB, increasing its index by 10; the remainder will be the log. sine of the acute angle LSB, which, being *added* to the angle of inclination (found as before), will give the *central angle* DSL: with this, and the distance SL, corresponding to the end of the eclipse or occultation, may be found the apparent difference of longitude between the sun and moon, and moon and star: this is to be added to the longitude of the sun or star at that time, if the central angle exceed 90°, otherwise subtracted: the sum, or difference, will be the apparent longitude of the moon corresponding, from which the time of the ecliptic conjunction may be obtained as before. If the central angle exceed 180°, the sine and cosine of the excess of that angle above 180° must be found instead of the sine and cosine of the central angle.

The apparent latitude of the moon is found as in the preceding rules, by making use of the central angle DSL, and the value SL, corresponding to the end of the eclipse or occultation; whence may be deduced the apparent latitude, and the error of the tables in latitude.

It is evident that both these methods ought to give the same results, and thus furnish a proof of the correctness of the calculations. All these calculations may be made by proportional logarithms, by reading in the rule, *log. cotangent* for log. tangent, *log. cosecant* for log. sine, &c., as was mentioned at the end of the rule in Problem V., and by using the constant log. 0.4771, instead of 3.55630.

---

* When SF = SL, the angle may be found as in the note with this mark in page 465.

† When this varies, it must be taken to correspond to the middle time between the immersion and true conjunction.

‡ See note with this mark in page 465.

Digitized by Google

EXAMPLE.

Suppose in a place in the latitude of 20° 0′ N., longitude 1h. 9m. 0s. east of Greenwich by estimation, the occultation of Spica by the moon on December 12, 1808, was observed, the immersion at 16h. 57m. 29s., emersion at 18h. 10m. 29s., apparent time, by astronomical computation. Required the longitude of the place of observation.

Most of the elements in the following Table are calculated by Problems I., II. and VI.

ELEMENTS OF THE OCCULTATION.	IMMERSION.	EMERSION.
	d. h. m. s.	d. h. m. s.
Apparent times of observation	12 16 57 29	12 18 10 29
Estimated longitude E. from Greenwich	1 9 0	1 9 0
Supposed apparent time at Greenwich	12 15 48 29	12 17 1 29
⊙'s right ascension	17 20 59.0	17 21 12.5
Lat. of place 20° 0′ — Reduc. Table XXXVIII. 7′ 22″	19° 52′ 38″	° ′ ″
Obliquity of the ecliptic	23 27 39	
☽'s long. by N. A. — Prob. I.	200 7 56.3	200 51 36.1
Longitude of the nonagesimal, by Prob. IV	149 15 55	165 28 58
☽'s long. — Long. nonagesimal = ☽'s distance from nonagesimal	50 52 1	35 22 38
This distance or its supplement to 360° is arch D	D 50 52 1	D 35 22 38
Altitude of nonagesimal, Prob. IV	81 17 32	74 35 18
☽'s horizontal parallax	59 52.3	59 54.4
— Reduction, Table XXXVIII	1.4	1.4
Reduced parallax	59 50.9	59 53.0
☽'s semi-diameter by N. A. — Inflection 2″	16 16.9	16 17.5
Add correction, Table XLIV.	10.4	13.3
☽'s corrected semi-diameter	SF 16 27.3	SL 16 30.8
☽'s horary motion in longitude by Prob. II. Example I.†	35 51.7	35 54.2
☽'s parallax in longitude	46 25	33 54
☽'s apparent longitude	200 54 21.3	201 25 30.1
Difference of ☽'s apparent longitudes	....	31 8.8
☽'s true lat. by N. A. Prob. I. South	1 55 11.0	1 51 29.1
☽'s parallax in latitude	10 23.6	17 38.4
☽'s apparent latitude south	2 5 34.6	2 9 7.5
✱'s true lat. = lat. Tab. XXXVII. 2° 2′ 13″.9 S. — Tab. XLI. 0″.6	2 2 13.3	2 2 13.3
Difference of ☽ ✱ apparent latitudes	FD = 3 21.3	EL = 6 54.2
Difference of ☽'s apparent latitudes	....	AL = 3 32.9
✱'s true long. = Long. Tab. XXXVII. 201° 10′ 29″.3 + Tab. XL. 11″.5 — Tab. XLI. 10″.1	201 10 30.7	

The difference of the apparent latitudes of the moon and star at the beginning of the occultation, 3′ 21″.3, being less than at the end, 6′ 54″.2, the angle of inclination is less than 90°. In this example the moon's latitude is more southerly than the star's; hence the points F, L, fall below the line DE.

Difference apparent long. ☽ 31′ 8″.8 = 1868″.8		Log.	3.27156	
☽'s mean apparent lat.	2 7 21	Cosine	9.99970	
Distance FA		Log.	13.27126	.... Log 3.27126
☽'s difference lat..... AL = 3 32.9 =	212.9	Log.	2.32818	
Inclination	83° 30′	Tang.	10.94308	Cosecant 10.00280
Apparent motion FL..	1879.6		....	.... Log. 3.27406
Its Arith. Comp.			6.72594	
SF + SL	= 32 58.1 = 1978.1	Log.	3.29625	
Difference SF, SL	3.5	Log.	0.54407	
Difference segments	3.7	Log.	0.56626	
Its half	1.8			
Half FL	939.8			
FB	938.0	Log.	2.97220	
SF	987.3	Log.	2.99445	
FSB	71° 49′	Sine	9.97775	
Inclination	83 30			
Diff. is central angle..	11 41	Cosine	9.99091	.... Sine 9.30643
SF		Log.	2.99445	.... Log. 2.99445
Star's latitude.	2° 2′ 13″	Sec.	10.00027	FD 199″.9 = 3′ 19″.9 Log. 2.30088
Diff. apparent long. ☽ ✱ 967″.5 =	16 7.5	Log	2.98563	
✱'s longitude	201 10 30.7			✱'s latitude 2 2 13 .3
☽'s apparent longitude..	200 54 23.2 by observation.			☽'s app. lat. 2 5 33 .2 by obs.
☽'s par. longitude	— 46 25			☽'s app. lat. 2 5 34 .6 by N. A.
☽'s true longitude	200 7 58.2	Constant	3 55630	Error Table — 1 .4 in latitude.
Difference true longitude 3752.5 =	1 2 32.5	Log.	3.57432	☽'s true lon. 200 7 58 .2 by obs.
☽'s horary motion....... 2153.5 =	35 53.5	Ar.Co Log.	6 66686	☽'s true lon. 200 7 56 .3 by N. A.
Time.........6273 =	1h. 44m. 33s.	Log.	3.79748	Error Table + 1 .9 in longitude
Immersion	16 57 29			
Conjunction	18 42 2 at place of observation.			
Conjunction	17 33 0 at Greenwich.			
Difference of meridians..	1h. 9m. 2s.			

† The moon's horary motion varies from 35′ 51″.7, to 35′ 54″.2, during the occultation: hence, at the middle time, 17h. 49m. 45s., between the immersion, 16h. 57m. 29s., and the conjunction, 18h. 42m. (deduced from the Nautical Almanac), the horary motion was 35′ 53″.5, as is easily found by a calculation similar to that in the Example of Problem VI

Digitized by Google

The difference of meridians deduced from the observation, 1h. 9m. 2s., differs but 2s. from the assumed quantity, 1h. 9m. 0s. If the difference had been considerable, it would have been necessary to repeat the operation with the difference of meridians thus calculated, and so on till the assumed and calculated longitudes agree. The errors of the tables above found, were deduced upon the supposition that the observations were actually made at the place mentioned in this example, and that the true longitude of the place of observation was 1h. 9m. 0s. For it must be observed, that the errors of the tables in longitude cannot be found by an observation of an eclipse or occultation, without knowing, by other observations, the precise longitude of the place of observation. This is evident by observing, that, by repeating the operation till the assumed and calculated longitude of the place of observation agree with each other, the longitude of the moon, deduced from the calculation, will agree also with the longitude by the tables. The time of conjunction at Greenwich, 17h. 33m. 0s., taken from the Nautical Almanac, is liable to a small error from the incorrectness of the tables. To obviate this error, it will be necessary to deduce (by the above method, or by Problem IX. when only the beginning or end is observed) the time of conjunction from observations actually made at two places; the difference of these times will be the difference of meridians free from the errors of the tables.

PROBLEM VIII

To find the longitude of a place by an eclipse of the sun, when the beginning or end only is observed; the apparent time being estimated from noon to noon, according to the method of astronomers; the latitude of the place being also known.

RULE.

To the apparent time apply the estimated longitude of the place in time, by adding if *west*, subtracting if *east*; the sum, or difference, will be the supposed time at Greenwich. Corresponding to this time in the Nautical Almanac, find, by Problem I., the moon's semi-diameter, horizontal parallax, longitude, and latitude; * and the sun's semi-diameter, longitude, and right ascension; also the moon's horary motion from the sun by Problem II. Decrease the sun's semi-diameter 3½″ for *irradiation*. Decrease the moon's semi-diameter 2″ for *inflexion*, if it be thought necessary, and to the remainder add the correction to Table XLIV.†; the sum will be the moon's *corrected* semi-diameter. Find also, in the Nautical Almanac, the obliquity of the ecliptic.

With these elements, and the apparent time at the place of observation, calculate the altitude and longitude of the nonagesimal by Problem IV., and the parallaxes in longitude and latitude, and the moon's apparent latitude by Problem V.

To the sum of the corrected semi-diameters of the sun and moon, *add* and *subtract* the moon's apparent latitude, and find the logarithms of the *sum* and *difference* in seconds. Half the sum of these two logarithms will be the logarithm ‡ of an arc in seconds, to be added to the sun's longitude if the phase is after the apparent conjunction, but subtracted, if before; § the sum, or difference, will be the *apparent* longitude of the moon. To this add the moon's parallax in longitude, when the moon's distance from the nonagesimal (found, as in Problem VI., by subtracting the longitude of the nonagesimal from the moon's longitude, borrowing 360° when necessary), is greater than 180°, otherwise subtracted; the sum, or difference, will be the *true* longitude of the moon.

Take the difference in seconds between the true longitudes of the sun and moon, and to its logarithm add the arithmetical complement log. of the moon's horary motion from the sun in seconds, and the constant logarithm 3.55630; the sum, rejecting 10 in the index, will be the logarithm ‡ of the correction of the given time, expressed in seconds. This is to be added to the apparent time of observation, when the moon's true longitude is less than the sun's, otherwise subtracted; the sum, or difference, will be the time of the true conjunction at the place of observation. The difference between this and the time of conjunction inferred from the Nautical Almanac for the meridian of Greenwich, by Problem III., will be the longitude of the place of observation in time, supposing the lunar and solar tables to be correct; but it is much more accurate to compare actual observations made at different places, by deducing the times of the ecliptic conjunction from each observation; the difference of these times will be the difference of longitude.

EXAMPLE.

At Salem, in the latitude of 42° 33′ 30″ N., longitude by estimation 4h. 43m. 32s. W. from Greenwich, the beginning of the total eclipse of June, 1806, was observed at 15d. 22h. 6m. 18s.1

* The longitude and latitude must be corrected for the errors of the tables, when known, by a previous operation, or by other observations

† This correction must be found after the altitude and longitude of the nonagesimal are calculated.

‡ These calculations may be made in the same manner by using proportional logarithms; the only difference consists in using the constant logarithm 0.4771, instead of 3.55630, in finding the time of conjunction.

§ In general, the beginning of an eclipse or occultation precedes the apparent conjunction, and the end is after the apparent conjunction; but there is a case (which very rarely occurs) where the contrary may take place; namely, where the point F or L (Plate XIV fig. 12, 13) falls between C and B, which can happen only when the lines FD, EL, are nearly equal to SF or SL. In this case, it may be ascertained whether the phase precedes or follows the conjunction, by making the calculation as in Problem VI. or VII., with the times of beginning and end, calculated by Problem XIII.; and, as the central angle is greater or less than 90°, the phase will follow or precede the apparent conjunction, the latitudes given by the tables being supposed correct.

Digitized by Google

apparent time, by astronomical computation. Required the longitude of the place from this observation.

The elements must be calculated, as in the Example of Problem VI., for the beginning of the eclipse, except those marked in italics. The rest of the calculation may be made by proportional logarithms, as follows :—

Sum semi-diameter ☉ ☽	32′ 23″.5		
☽'s apparent latitude............	1 55 .8		
Sum....................	34 19 .3	...............Prop. Log.	0 7197
Difference..............	30 27 .7	...............Prop. Log.	0.7715
		Sum	1.4912
Half sum.....................Arc	32 20	corresponding to Prop. Log.	7456
☉'s longitude....................	84 41 3.4		
☽'s apparent longitude...........	84 8 43.4		
☽'s par. longitude................	— 19 46.8		
☽'s true longitude................	83 48 56.6		
☉'s true longitude...............	84 41 3.4	Constant Log.	0.4771
Difference.........................	52 6.8	...............Prop. Log.	0.5383
☽'s horary motion from ☉........	34 17.1	Arith. Comp. Prop. Log.	9.2798
Time from conjunction......	1h. 31m. 13s.	...............Prop. Log.	0.2952
Apparent time observation...	15 22 6 18		
Apparent conjunction Salem.	15 23 37 31		
App. conjunction Greenwich	16 4 19	by Nautical Almanac.	
Difference of meridians......	4h. 41m. 29s.		

If we suppose the time of conjunction at Greenwich to be 4h. 20m. 47s. as calculated in the Example, Problem VI., the difference of meridians would be 4h. 43m. 16s., agreeing nearly with the assumed longitude, so that it will not be necessary to repeat the operation. The remarks at the end of that example, respecting the errors of the lunar tables, and the comparing of actual observations at different places, are equally applicable to the present problem.

PROBLEM IX.

To find the longitude of a place by an occultation of a fixed star by the moon, when the immersion or emersion only is observed; the apparent time being estimated from noon to noon, according to the method of astronomers, and the latitude of the place being known.

RULE.

To the apparent time apply the estimated longitude of the place turned into time, by adding if *west*, subtracting if *east;* the sum or difference will be the supposed time at Greenwich. At this time find in the Nautical Almanac the sun's right ascension, the moon's semi diameter, horizontal parallax, longitude, and latitude,* by Problem I.; and the moon's horary motion by Problem II.; also the latitude and longitude of the fixed star by Table XXXVII. and correct it for aberration and equation of equinoxes by Tables XL. XLI. Decrease the moon's semi-diameter 2″ for inflexion, if it be thought necessary, and to the remainder add the augmentation from Table XLIV.;† the sum will be the *corrected* semi-diameter. Find also, in the Nautical Almanac, the obliquity of the ecliptic. With these elements, and the apparent time of observation, calculate the altitude and longitude of the nonagesimal by Problem IV., also the parallaxes in longitude and latitude of the moon's apparent latitude by Problem V.

Take the difference between the latitude of the star and the apparent latitude of the moon which add to and subtract from the moon's corrected semi-diameter (these quantities being expressed in seconds); half the sum of the logarithms of these quantities, increased by the log. secant of the star's latitude, rejecting 10 in the index, will be the logarithm ‡ of an arc in seconds, to be added to the star's longitude if the moon has passed the apparent conjunction, but subtracted if *before;*§ the sum, or difference, will be the *apparent* longitude of the moon. To this add the moon's parallax in longitude when the moon's distance from the nonagesimal (found as in Problem VII., by subtracting the longitude of the nonagesimal from the moon's longitude, borrowing 360° when necessary) is greater than 180°, otherwise subtract it; the sum or difference will be the *true* longitude of the moon. Take the difference in seconds between the moon and star's true longitudes, and to its logarithm add the arithmetical comp. log. of the moon's horary motion, and the constant logarithm 3.55630, the sum, rejecting 10 in the index, will be the logarithm ‡ of a correction in seconds to be applied to the given time of observation by *adding* when the moon's true longitude is less than the star's, otherwise *subtracting;* the sum or difference will be the time of the true

* Corrected for the errors of the tables in longitude or latitude when known.
† This correction must be found after the alt tude and longitude of the nonagesimal are calculated.
‡ Proportional logarithms may be used instead of common logarithms, the constant logarithm being 0.4771, instead of 3.55630, and the log. cosine being used instead of log. secant.
§ See note with this mark in page 470.

Digitized by Google

conjunction at the place of observation. The difference between this and the time of conjunction inferred from the Nautical Almanac by Problem III., for the meridian of Greenwich, will be the longitude of the place of observation, if the tables are correct; but it is much more accurate to compare the times of conjunction deduced from actual observations at the different places in the manner mentioned at the end of the rule given in Problem VII.

EXAMPLE

Suppose in a place in the latitude of 20° 0′ N., longitude by estimation 1h. 9m. 0s. east from Greenwich, the emersion of the star Spica was observed on December 12, 1808, at 18h. 10m. 29s., apparent time, by astronomical computation. Required the longitude of the place of observation.

The elements must be calculated as in the example of Problem VII., for the emersion of Spica. The rest of the calculation, made by common logarithms, is as follows:—

☽'s semi-diameter	16′ 30″.8 = 990″.8		
Difference apparent lat. ☽ ✱	6 54 .2 414 .2		
Sum	1405 .0	Log.	3.14768
Difference	576 .6	Log.	2.76087
Sum	5.90855 its half		2.95427
✱'s latitude 2° 2′ 13″		Sec.	10.00027
Arc	15′ 0″.6 = 900″.6	Log.	2.95454
✱'s longitude	201 10 30 .7		
☽'s apparent longitude	201 25 31 .3		
☽'s par. longitude	— 33 54		
☽'s true longitude	200 51 37 .3	Constant	3.55630
Difference true longitude ☽ ✱.	18 53 .4 = 1133 4	Log.	3.05438
☽'s horary motion	35 54 .7 = 2154 7	Arith. Comp. Log.	6.66661
Time	0h. 31m. 34s. = 1894	Log.	3.27729
Time of observation	18 10 29		
Conj. at place of observation.	18 42 3 by observation.		
Conjunction at Greenwich	17 33 0 by Nautical Almanac		
Difference of meridians	1h. 9m. 3s.		

The difference of meridians by calculation, 1h 9m. 3s, differs but 3s. from the assumed longitude, so that it will not be necessary to repeat the operation. All the remarks made at the end of the example in Problem VII. are applicable to this problem. It may also be further observed, that the emersion or immersion which happens on the dark limb of the moon can be observed with much more accuracy than on the enlightened limb; because the light from this limb prevents the observer from perceiving the star's immersion or emersion so instantaneously as on the dark side of the moon.

PROBLEM X.

To calculate an eclipse of the moon.

The time of beginning or end of a lunar eclipse at any place may be found by subtracting or adding the longitude to the times given in the Nautical Almanac for the meridian of Greenwich, according as the longitude is west or east. But as some readers may wish to know the method of deducing these times from the longitudes, latitudes, &c. of the moon and sun, given by the Nautical Almanac or by other tables, it was thought proper to insert the rule for these calculations.

An eclipse of the moon can only happen at the time of the full moon. If her longitude at that time is not distant from either node† of the moon's orbit more than about 12°, there may be an eclipse. To find whether there will be one, and to calculate the times and phases, proceed as follows:—

RULE.

Find the time of full moon at Greenwich by the Nautical Almanac or Problem III., to which *add* the longitude of the place turned into time, if *east;* but *subtract* if *west;* the sum or difference will be the time of the ecliptic opposition at the proposed place.

For the time at Greenwich, find, by Problem I., the moon's latitude, horizontal parallax, and semi-diameter (which requires no augmentation); also the sun's semi-diameter; then, by Problem II., the horary motion of the moon from the sun in longitude, and the moon's horary motion in latitude.

Draw the line ACB (Plate XIV. figure 6); and, perpendicularly thereto, the line PCR. Select a scale of equal parts to measure the lines of projection, and from it take CG, equal to the moon's latitude, and set it on CR from C to G, *above* the line AB if the latitude of the moon is *north*, below if south.‡ Take CO, equal to the horary motion of the moon from the

† The longitude of the moon's ascending node is given in the Nautical Almanac. The longitude of the other node is found by adding or subtracting 6 signs

‡ The northern latitudes found by Problem I. have the sign —, the southern + In the figure the latitude is south If it had been north, the point G must have been placed on the continuation of RC above C

Digitized by Google

sun in longitude, and set it on the line CB to the right of C, from C to O. Take CP, equal to the moon's horary motion in latitude, as found with its sign by Problem II., and set it on the line CR, from C to P; *above* the line AB if its sign is —, *below** if +. Join OP, which is equal to the horary motion of the moon from the sun, and parallel thereto through G draw the relative orbit of the moon from the sun NGL, on which are to be marked the places of the moon before and after the full, by means of the horary motion OP, so that the moment of full moon, or ecliptic opposition at the proposed place, may fall exactly on the point G. This may be done by making the extent OP equal to the transverse distance of 60, 60, on the line of lines of the sector, then measuring from the same lines the transverse distance corresponding to the minutes and parts of a minute in the time of full moon at the place of observation, and setting it on the line GN from G towards the right to the point x, where the whole hour preceding the full moon is to be marked.† Then the distance OP set from x to the right hand on the line LGN reaches to the hours preceding the full moon, and set to the left hand reaches successively to the following hours. These intervals are to be divided into 60 equal parts, representing minutes, if the size of the scale will admit of it.

Add 50″ to the moon's horizontal parallax,‡ and from the sum subtract the sun's semi-diameter; the remainder will be the semi-diameter of the shadow CB, with which describe the circle ASB about the centre C. Add the moon's semi-diameter to the radius CB, and with that radius describe, about the centre C, the circle DRM; which, if there be an eclipse, will cut NL in the points E, H, representing respectively the places of the moon at the beginning and end of it. If there is no intersection, there will be no eclipse. Draw the line CKST perpendicular to LN, cutting it in K, and meeting the circles ASB, DRH in S, and T. With a radius equal to the moon's semi-diameter, describe about the centres E, H, K, the small circles represented in the figure; of which that drawn round K cuts the line CKS in the points I, F; and if the eclipse is total, the whole of this circle will fall within ASB, as in fig. 6; but if part of the circle falls without ASB, as in fig. 7, Plate XIV., the eclipse will be partial. In either case, the number of digits eclipsed may be obtained by saying, As the diameter of the moon FI, is to the obscured part FS, so are 12 digits to the number of digits eclipsed. When the eclipse is total, the beginning and end of total darkness may be found by taking a radius equal to CB, decreased by the moon's semi-diameter, and sweeping with it round the centre C, a circle *d e h m*, cutting LN in the points *e*, *h*, representing respectively the points of beginning and end of total darkness. Then the hours and minutes marked in the line NL, at the points E, *e*, K, *h*, H, will represent respectively the times of the beginning of the eclipse, beginning of total darkness, middle of the eclipse, end of total darkness, and end of the eclipse. In this rule no allowance is made for the oblate figure of the earth, the correction from this source being much less than the errors of observation.

EXAMPLE.

Required the times of beginning, end, &c., of the eclipse of the moon of May 9, 1808 at a place in the longitude of 30° W. from Greenwich.

By the Nautical Almanac the time of full moon at Greenwich was May 9th, at 19h. 39m. From this subtracting the longitude of the place of observation, 30° W., or 2h., the remainder, 17h. 39m., was the time of full moon at the place of observation. Corresponding to the time at Greenwich, 19h. 39m., the elements in the adjoined table were calculated by Prob. I. and II., and the values CB, CD, C*d*, found by the above rule. Upon the centre C, with the radii CB, CD, C*d*, taken from a scale of equal parts, describe the circles ASB, MRD, *mrd*. Draw the line ACB, representing the ecliptic, and make CG, perpendicular thereto, equal to the moon's latitude, 10′ 44″.8 S.; the point G being taken below C, because that

ELEMENTS OF THE ECLIPSE, MAY 9, 19H. 39M.	
App. time of conjunction at Greenwich, May 9...	19h. 39m.
Longitude place 30° W..........	2 0
App. time of conjunction at place of observation..	17 39
☽'s lat. by Prob. I. S. decreasing..........CG	+ 10′ 44″.8
☽'s horizontal parallax..........	61 13 .5
☽'s semi-diameter..........BD	16 40 .7
☉'s semi-diameter..........	15 51 .3
☽'s horary motion in longitude, Prob. II..........	37 37 .8
☉'s horary motion in longitude..........	2 24 .8
☽'s horary motion from ☉ in longitude.......CO	35 13 .0
☽'s horary motion in latitude, Prob. II........CP	— 3 26 .2
☽'s hor. parallax + 50″ — ☉'s semi-diam.. = CB	46 12 .2
CB + ☽'s semi-diameter.......... = CD	62 52 .9
CB — ☽'s semi-diameter.......... = C*d*	29 31 .5

* In other words, the point P will fall above C if the moon is approaching to the north pole of the ecliptic, otherwise below: that is, the point P must fall *above* C if the moon's latitude is *south decreasing* or *north increasing*, otherwise below. When no great accuracy is required, the horary motion in latitude need not be found by Problem II. Instead of which, the angle COP may be taken equal to 5° 40′, in eclipses of the moon or sun, and the line OP equal to CO increased by 9″ or 10″: but this method will not answer in occultations in which the angle COP varies above 5 degrees.

† The distance Gx may also be found by common arithmetic, by saying, As 60 minutes are to the minutes and seconds in the time of full moon (which in the present example is 39′), so is OP to Gx. After marking the hours on the line LGN, it is usual to divide them successively into halves and quarters of an hour, then into five minutes and one minute.

‡ The semi-diameter of the shadow is increased by the earth's atmosphere from 20″ to 60″, according to the estimates of different astronomers. Mayer supposes this correction to be one 60th part of the shadow, varying from 37″ to 46″. The mean of Mayer's correction added to the sun's parallax is nearly equal to 50″ assumed as above.

Digitized by Google

latitude is south. Make CO equal to the horary motion of the moon from the sun in longitude, 35′ 13″.0, and CP perpendicular thereto equal to the horary motion in latitude, —3′ 28″.2, the point P being placed above C, because the moon's horary motion in the latitude has the sign — prefixed; or, in other words, the latitude was south decreasing. Join OP, and parallel thereto draw through G the line NGL, and on it let fall the perpendicular CK. Make the distance OP a transverse distance of 60, 60, on the line of lines of the sector, and measure from the same lines the transverse distance 39, 39 (corresponding to the minutes in the time of full moon at the place of observation); this distance, set on the line GN, to the right of G, reaches to the point x, where the hour, 17h., preceding the full moon, is to be marked. Take the extent OP, and lay it from 17h. to the right hand to 16h., and successively to the left to 18h. 19h., &c. Subdivide these lines into 60 equal parts, representing minutes, if the scale will permit, and the times corresponding to the points E, e, K, k, H, will represent respectively the beginning of the eclipse, 15h 56m.; the beginning of total darkness, 16h. 54m.; the middle of the eclipse, 17h. 41m.; the end of total darkness, 18h. 28m.; and the end of the eclipse, 19h. 26m; which times agree nearly with those in the Nautical Almanac, allowing for the difference of meridians 2 hours.

CALCULATION BY LOGARITHMS.

The phases of the eclipse may also be calculated by logarithms in a very simple manner. Thus, suppose it was required to find the time of the beginning of the eclipse in the above example. In this case, in the right-angled triangle OCP, there would be given CO=2113″.0, and CP=208″.2, to find OP=2123″.2, and the angle OPC=84° 22′. This angle is equal to RGE, because GE, OP, are parallel, and its supplement gives the angle CGE=95° 38′. Then, in the triangle CGE, there are given the angle CGE=95° 38′, the moon's latitude CG=644″.8, and the line CE (=CD)=3772″.9, to find CEG=9° 48′, GCE=74° 34′, and GE=3654″.5. Then say, As OP (2123″.2) is to 1 hour (3600s.), so is GE (3654″5.) to the time (6196s.=), 1h. 43m. 16s., between the beginning of the eclipse and the full moon at the place of observation, 17h. 39m.; and as the point E falls to the right hand of G, that time must be subtracted from 17h. 39m., to obtain the time of the beginning of the eclipse, 15h. 55m. 44s., which agrees nearly with the projection. As these calculations are very simple, it will be unnecessary to take notice of the different cases, or to give the calculations at full length, the whole being sufficiently evident from the figure. The middle of the eclipse is found by means of the triangle GKC, similar to OCP, in which the angles and hypotenuse CG are given to find CK, KG. The time of describing KG being added to, or subtracted from the time of full moon at the place of observation, according as the point K falls to the left or right of G, will give the time of the middle of the eclipse. The distance CK, 10′ 41″.7, subtracted from the radius CD or CT=62′ 52″.9, will leave a remainder equal to the eclipsed part FS (=KT), 52′ 11″.2; and the moon's diameter, 33′ 21″.4, is to FS, 52′ 11″.2, as 12 digits to the digits eclipsed, 18¾. In making these calculations, common or proportional logarithms may be made use of.

PROBLEM XI.

To project an eclipse of the sun for any given place.

An eclipse of the sun can happen only at the time of new moon. If the moon's longitude at that time is not distant from either node of the moon's* orbit more than 17½°, there may be an eclipse. To find whether there will be one, and to calculate the times and phases, proceed by the following

RULE.

To the time of the new moon, given in the Nautical Almanac (or calculated by Prob. III.), add the longitude of the proposed place, turned into time, if east; but subtract if west; the sum or difference will be the time of conjunction at the proposed place. Corresponding to the time of new moon at Greenwich, find, by Problem I., the moon's latitude, horizontal parallax, and semi-diameter; also the sun's longitude, semi-diameter, and declination. Then, by Problem II., find the horary motion of the moon in latitude, and the horary motion of the moon from the sun in longitude.

Draw the line ACB (Plate XIV. fig. 10), representing the ecliptic, and, perpendicularly thereto, the line PCR. Take a scale of equal parts to measure the lines of the projection; measure from it an interval equal to the moon's latitude, and apply it on CR from C to G; *above* the line ACB if the moon's latitude is *north*, *below* if *south*.† Take CO, equal to the horary motion of the moon from the sun in longitude, and set it on the line CB, to the right hand of C to O; take CP, equal to the moon's horary motion in latitude, found by Problem II., and set it on the line CR, from C to P; *above*‡ the line ACB if the sign is —, *below* if +. Join OP, which represents the horary motion of the moon from the sun on the

* See note with the mark † in page 472. All the eclipses that can happen in any part of the earth are indicated in the Nautical Almanac.

† In the figure, the latitude is supposed north. If it had been as much south, the point G would have been as much below C as it is now above it.

‡ See note with the mark * in page 473.

Digitized by Google

relative orbit, and parallel to that line draw the relative orbit of the moon, NGL, on which are to be marked the places of the moon before and after the conjunction, by means of the horary motion OP, so that the moment of the new moon, or ecliptic conjunction, at the proposed place may fall exactly on the point G, as in the figure, where the new moon is at 23h 35¼m. This may be done by taking the extent OP, equal to the transverse distance of 60, 60, on the line of lines of the sector, then measuring from the same lines the transverse distance corresponding to the minutes and parts of a minute of the time of new moon at the place of observation, and setting it on the line GN from G towards the right hand to the point *x*,* the place of the moon at the first whole hour preceding the conjunction (which in the present figure is 23h.) Then the distance OP being taken in the compasses, and set from *x* to the right hand, gives successively the hours preceding the new moon; and the same distance set to the left gives the following hours, as in the figure, where they are marked in succession 22h., 23h., 24h., 1h. These hours are to be divided into 60 equal parts, representing minutes, the scale being taken sufficiently large for that purpose.† In the present figure, the subdivisions are carried only to five minutes.

From the moon's horizontal parallax subtract the sun's, 8″.6; the remainder is to be taken from the scale of equal parts for the radius CB, with which, on the centre C, describe the circle BRA, cutting CR in R. Open the sector till the transverse distance of 60°, 60°, on the line of chords, is equal to the radius CB, and measure from the same lines the transverse distance 23° 28′ (equal to the obliquity of the ecliptic), which set on the circle ARB on each side of R to T and U. Join TU, cutting CR in Q. On Q as a centre, with the radius QT, describe the circle TVU, on which set off the arc TV equal to the sun's longitude. Through V draw the line VP′ parallel to CR to cut TU in P′, the place of the pole of the earth.‡ Draw CP′, and continue it on either side so as to cut the circle ARB in the point W, situated *above* AB if the latitude of the proposed place is *north*, *below* if *south*. In the present figure, the latitude is north. If it had been south, the lower part of the circle ARB ought to have been made use of. Open the sector so as to make the transverse distance 60°, 60°, on the chords, equal to CB, and measure off the transverse distance equal to the chord of the complement of the latitude of the place, which set from W on each side to D and *d*. With the same opening of the sector measure the chord of the sun's declination, and set it on the same circle from D on each side to E and F, and from *d* on each side to *e* and *f*. Draw the dotted lines F*f*, D*d*, E*e*, cutting CW in *l*, *q*, *n*. Bisect *ln* in *r*, and erect the line VI *r* XVIII, perpendicular to CW, and make *r* VI and *r* XVIII, each equal to *q*D. Open the sector to make the transverse distance 90°, 90°, on the sines, equal to *q*D and measure off the transverse distance corresponding to 15°, 30°, 45°, 60°, 75° (or 1, 2, 3, 4, 5 hours), which set on each side of the point *r*, on *r* VI and *r* XVIII, to the points marked with the numbers 15°, 30°, &c. Through these points draw the lines I XI, II X, III IX, &c., as in the figure, parallel to CW. Open the sector so as to make *rn* equal to the transverse distance of 90°, 90°, on the sines, and measure the complements of the former degrees as transverse distances on the sines, viz. 75°, 60°, 45°, 30°, 15°, and set them on the above lines I XI, II X, &c. from the points of intersection with the line VI *r* XVIII, above and below that line. The points I, II, III, &c. obtained in this manner, will represent the situation of the spectator at the proposed place, at those hours, and a regular curve drawn through these points will represent his path. In marking the hours, it must be observed, that the place of noon will be at the *lower point n*, if the sun's declination is *north*; but at the *upper point l*, if the declination is *south*: the hours must be marked from noon towards the left in numerical succession completely round the curve, ending at 24h., according to the method of astronomers. In the present figure, the declination is north

* See note with this mark † in page 473.

† The scale I generally make use of, is one inch to ten minutes, reducing the seconds to decimals of a minute. Thus, 50′ 36″ in decimals is 50′.6, which by this scale would be 5.06 inches, obtained by placing the decimal point one figure to the left.

‡ This may also be found as follows:—After drawing TQU, as above, open the sector till the transverse distance 90°, 90°, on the sines, is equal to QT; then measure from that line the extent QP′ as a transverse distance corresponding to the sine of the difference between the sun's longitude and 90° or 270°. When the sun's longitude exceeds 6 signs, the point V will fall in the semi-circle below TU. This is not drawn in the figure, for want of room. When the longitude exceeds 2, 4, 6, &c. signs, it will be convenient to mark on the circle TYU the points corresponding to those signs, by setting off the radius QT as a chord from T to ♊, from ♊ to ♌, &c., and then taking from the sector the chord corresponding to the excess of the given longitude above that of the point ♊, ♌, &c. immediately preceding. Thus, if the sun's longitude be 84° 44′, it will be convenient to set off 60° from T to ♊, and 24° 44′ from ♊ to the sought point, V.

In case of not having a sector, an arc, as RT, may be marked off by a plane scale, even when the radius CR differs from that of the scale, by drawing, by Problem VI. of Geometrical Problems, the line CT, making an angle with CR equal to the proposed arc, 23° 28′. The intersection of that line with the circle ARB will give the sought point, T. In a similar manner the point V may be found by drawing a line, QV, making the angle TQV equal to the proposed arc, TV. The points 15°, 30°, 45°, &c. on the line VI *r* XVIII, may be found by describing on that line as a diameter, and on *r* as a centre, a semi-circle, which is to be divided into 12 equal parts of 15° each. The dotted lines drawn through these points perpendicular to the diameter VI *r* XVIII, will cut it in the sought points, 15°, 30°, &c. This circle is not drawn in the proposed figure, to prevent confusion. Draw the line VI *k* perpendicular to *r* VI, and equal to *rn*. Join *rk* cutting the lines 75° V, 60° IV, &c. in the points 1, 2, 3, 4, 5. Make the lines 15° I, 30° II, 45° III, &c. respectively equal to 75° 1, 60° 2, 45° 3, &c., and the sought points, I, II, III, &c. will be obtained. This method may be used when the line *rn* is too small to be taken from the sector. The same method may be made use of in projecting an occultation, by drawing *tk* (fig. 8, Plate XIV.) perpendicular to *rt* and equal to *rn*, and joining *rk* to cut the dotted lines drawn parallel to CP′ in the points 1, 2, 3, &c. as above.

Digitized by Google

and the point n the place of noon or 0 hours. If it had been south, the point l would have been marked 0h., and the points marked XI, X, &c. would be I, II, &c. respectively. The path touches the circle ARB in two points, representing the points of sun rising and setting, which, in the present figure, are respectively 16h. 26m. and 7h. 34m. These points divide the path into two parts, of which one represents the path by day, the other by night, as is evident from the hours marked on the curve. Half hours, or any other intermediate time, may be marked in a similar manner. Thus, for the time 3h. 30m. = 52° 30′, set the sine of 52½° to the radius r VI, from r to h on the line r VI, and erect the perpendicular hi equal to the sine of 37½° (which is the complement of 52½°) to the radius rn, and the point i will be the place of the spectator at the proposed time. In this way the halves and quarters of hours may be marked on those parts of the path where necessary. The smaller subdivisions may generally be obtained to a sufficient degree of accuracy by dividing the quarters of hours into equal parts.

Take from the scale of equal parts an extent equal to the sum of the semi-diameters of the sun and moon, and, beginning near N, find, by trials, the point p' of the moon's path, and the point Z' of the path of the spectator, marked with the same time and at that distance apart. That time will be the beginning of the eclipse. If no such points can be found, there will be no eclipse at the proposed place. Proceed in the same way towards the point L, and find the points p'', Z'', at the same distance apart, the corresponding time will be the end of the eclipse. Find, by trials, the point p of the moon's path, and the point Z of the path of the spectator, marked with the same times at the nearest distance from each other (which will in general be nearly the middle time between the beginning and end of the eclipse); that time will be the middle of the eclipse. On Z as a centre, with a radius equal to the sun's semi-diameter, describe the circle whose diameter is Ss, representing the sun's disc; and on the centre p, with a radius equal to the moon's semi-diameter, describe the circle whose diameter is Mm, representing the moon's disc. The part of the sun's disc that is cut off by this circle will represent the part of the sun that is eclipsed. In the example of figure 10, the centre, p, of the moon's disc is so near that of the sun, Z, that the eclipse is nearly central; and, as the moon's semi-diameter is greater than the sun's, the eclipse must be *total*. Under similar circumstances, if the moon's semi-diameter had been least, the eclipse could have been *annular*. In case of a partial eclipse, the sun's disc will not be wholly covered by the moon, as in figure 11, Plate XIV., where the circles representing the discs of the sun and moon are marked with the same letters as in figure 10, but the objects are placed in a different situation. In this case, the number of digits eclipsed may be obtained by drawing a line through the centres p, Z, to meet the discs in the points S, M, s, m, and by saying, As the distance Ss (representing the whole disc) is to the obscured point Ms, so are 12 digits to the number of digits eclipsed. The beginning and end of total darkness in a total eclipse are found like the beginning and end of the eclipse, except in taking in the compasses the difference between the semi-diameters of the sun and moon, instead of their sum. For the points of the path of the spectator and of the moon's orbit, marked with the same time, and at that distance from each other, will represent the situations and times of the beginning and end of total darkness. The beginning and end of the internal contacts of an annular eclipse are found in the same manner; the only difference is that, in a total eclipse, the moon's semi-diameter is greatest, but in an annular eclipse the least.

In observing the beginning of a solar eclipse, it is of some importance for the accuracy of the observation, to know on what part of the sun's limb the eclipse will begin. This is easily found by means of the projection. Thus at the beginning of the eclipse, which corresponds to the point p' of the moon's path, and the point Z' of the path of the spectator, the first point of contact g may be obtained by drawing about the centre p', with a radius equal to the moon's semi-diameter, a circle representing the moon's disc;* about Z' as a centre, with a radius equal to the sun's semi-diameter, another circle representing the sun's disc, touching the former in the point g. Draw the line CZ', meeting the sun's disc in the points a, c, the point c being the most distant from the centre C. Then the circle $g\ a\ c$, being held between the eye of the observer and the sun, the engraved or marked side of the figure towards the eye, and the line $c\ a$ in a vertical direction with the point c uppermost, will represent the appearance of the sun as viewed by the naked eye at that time; c will represent the upper part of the sun, a the lower, and g the point of contact. If the eclipse be observed with an inverting telescope, the contrary will be observed; that is, the part a must be uppermost, c the lowest, and g, the point of contact, will appear to the left hand of $c\ a$. In a similar manner the appearance of the objects may be obtained at any other part of the eclipse, but it is not necessary except at the beginning of it, where there is nothing to direct the eye of the observer.

* Instead of this circle, the line $p'\ Z'$ may be drawn cutting the sun's disc in the sought point of contact g.

Digitized by Google

EXAMPLE.

Required the times and phases of the total eclipse of the sun, June 16, 1806, at Salem, in the latitude of 42° 33′ 30″ N., and the longitude of 4h. 43m. 32s. west from Greenwich.

By the Nautical Almanac, the time of new moon at Greenwich was June 16d. 4h. 19m., corresponding to June 15, 23h. 35m. 28s., at Salem. At the time at Greenwich, 4h. 19m. the elements of the eclipse were, as in the adjoined table, calculated by the above rule.

ELEMENTS	h.	m.	s.
Conjunction at Greenwich, June 16....	4	19	00
Salem W. from Greenwich............	4	43	32
Ecliptic conjunction at Salem, June 15.	23	35	28
Latitude of Salem	42°	33′	30″
☽'s horizontal parallax..................		60	25.7
⊙'s horizontal parallax..................			8.6
☽'s reduced horizontal parallax.........		60	17.1
☽'s semi-diameter........................		16	28.1
⊙'s semi-diameter........................		15	46.1
Sum of semi-diameters....................		32	14.2
Difference of semi-diameters............			42.0
☽'s horary motion in longitude, Prob. II.		36	41.2
⊙'s horary motion.........................		2	23.1
☽'s horary motion from ⊙............CO		34	18.1
☽'s horary motion in latitude ....CP	+	3	22.5
☽'s latitude by Prob. I..............CG	−	19	37
⊙'s longitude ....TV	84	44	36
⊙'s declination......................DF	23	22	N.

Draw ACB (Plate XIV. fig. 10), and perpendicular thereto the line CGR. Make CG equal to the moon's latitude, 19′ 37″ N., taken from a scale of equal parts, the point G being above C because the latitude is north. Make CO equal to the moon's horary motion from the sun, 34′ 18″.1, to the right hand of the point C; and CP equal to the moon's horary motion in latitude + 3′ 22″.5, the point P being below C because this horary motion has the sign + prefixed. Draw NGL parallel to OP. Make OP a transverse distance of 60, 60, on the line of lines of the sector, and measure from the same lines the transverse distance 35½, 35½ (corresponding nearly to the minutes in the time of new moon) this distance, set on the line GN to the right of G, reaches the point *x*, where the hour preceding the new moon is to be marked, viz. 23h. Take OP in the compasses, and mark it successively on the line NL from *x*, or 23h., to the right to 22h., and to the left to 24h. or 0h., 1h., &c. These are subdivided into five minutes, the scale not admitting smaller divisions. Take the moon's reduced horizontal parallax, 60′ 17″.1, from the scale of equal parts, and with that radius describe about the centre C the circle ARB. Set off (by means of the sector) the arcs RT, RU, each equal to 23° 28′. Join TQU, and about that diameter describe the circle TYU. Make the arc TV equal to the sun's longitude, 84° 44′ 36″ which is done by setting the radius QT as a chord from T to ♊, and then the arc ♊V = 24° 44′ 36″ by means of the sector. Draw P′V parallel to CR, to meet TU in the point P Join CP′, and continue it to meet the circle ARB in W. Make (by the sector) the arcs WD, W*d*, equal to the complement of the latitude of the place, 47° 26½′ nearly, the radius being CB. In a similar manner make the arcs DF, DE, *df*, *de*, &c., each equal to the sun's declination 23° 22′. Draw the lines F*lf*, D*qd*, E*ne*, cutting CW in *l*, *q*, *n*. Bisect *ln* in *r*. Draw the line VI *r* XVIII parallel to D*qd*, and make *r* VI, *r* XVIII, each equal to *q*D. Through the points *l*, VI, *n*, XVIII, *l*, draw the path of the spectator as taught in the above rule, and mark the hour of noon, 0h., at the point *n* because the sun's declination is north. Mark the following hours in succession to the left, I, II, III, &c., as in the figure. Take an extent in the compasses equal to the sum of the semi-diameters of the sun and moon, 32′ 14″.2, and, beginning towards N, find, as above directed, the points *p*′Z′ at that distance apart and marked with the same time, 22h. 7m. nearly, which is the time of the beginning of the eclipse. Proceed in the same way for the end of the eclipse corresponding to the points *p*″, Z″, and to the time 0h. 53m., which is the time of the end of the eclipse. Take the difference of the semi-diameters of the sun and moon, 42″, in the compasses, and proceed in the same way to find the beginning and end of total darkness, 23h. 27m., and 23h. 31m. The points corresponding could not be drawn in the figure, as they are so near to *p* and Z, and the scale small. Find, by trials, the points *p*, Z, marked with the same time and at the least distance apart; this will be the time of the middle of the eclipse, 23h. 29m. With an extent equal to the moon's semi-diameter, 16′ 28″.1, as a radius, describe about *p* the circle whose diameter is M*m* representing the moon's disc; and with the sun's semi-diameter, 15′ 46″.1, describe about Z the circle whose diameter is S*s*, representing the sun's disc at the middle of the eclipse. The sun's disc being wholly covered by the moon, indicates that the eclipse was total. Describe, in the same way, about *p*′ and Z′ the discs of the sun and moon, at the beginning of the eclipse, touching each other in *g*. Draw CZ′, cutting the moon's disc in *c* and *a*. Then the arc *c g* will be the distance of the first point of contact of the sun and moon from the sun's zenith towards the western part of the limb.

REMARKS.

1. The correction for the spheroidal form of the earth, the augmentation of the moon's semi-diameter, inflexion and irradiation, are neglected in the above rule, as not sensibly affecting the result of the projection, though these points might be attended to by the following precepts.

2. From the latitude of the place subtract the correction of latitude of Table XXXVIII, and from the moon's horizontal parallax, decreased by 8″.6, subtract the correction of parallax in the same table; the remainders will be the corrected latitude and parallax to be made use of in the above rule to correct for the spheroidal form of the earth.

Digitized by Google

3. Decrease the moon's semi-diameter given by the Nautical Almanac by 2″ for inflexion, if it be thought necessary.

4. Decrease the sun's semi-diameter 3½″ for irradiation, and from the remainder subtract a correction equal to the augmentation (Table XV.) that the moon's semi-diameter would have when at the same altitude as the sun; the remainder will be the corrected semi-diameter of the sun, to be used in the above rule in finding all the times and phases of the eclipse. This method of decreasing the sun's semi-diameter produces nearly the same result as that by augmenting the moon's semi-diameter, horary motion, and horizontal parallax, and taking the sun's semi-diameter as given in the Nautical Almanac.

5. Besides these corrections, there are others, depending on the change of the moon's semi-diameter, horizontal parallax, and horary motion during the eclipse; but all these corrections are usually neglected in projecting an eclipse or occultation.

6. The altitude of the sun, which is nearly the same as that of the moon during the eclipse, may easily be found by means of the projection. Thus, if it were required at the beginning of the eclipse, when the spectator is at Z′: Take the distance CB, and apply it as a transverse distance 90°, 90°, to the sines of the sector; then the distance CZ′, applied in the same manner to those lines, will give the zenith distance of the sun, about 31°, corresponding to the altitude 59°. The correction (Table XV.) corresponding to this altitude is 14″, which is nearly the correction to be subtracted from the sun's semi-diameter, 15′ 42″.6 (corrected for irradiation), to obtain the corrected semi-diameter, 15′ 28″.6, as taught in §4. Table XV. was calculated for the mean semi-diameter, 15′ 37″, and the correction of the Table, 14″, ought to be increased in ratio of the sun's semi-diameter, 15′ 46″.1, to 15′ 37″, when very great accuracy is required. The difference of the corrected semi-diameters of the sun and moon, 15′ 28″.6 and 16′ 26″.1, is 57½″, which is to be used instead of 42″ in finding the beginning and end of total darkness. The duration of the total darkness found by the corrected value 57½″, is 4¾ minutes, but with the uncorrected value 42″, is only 3½ minutes. It was probably owing to the neglect of this correction that some of the Almanacs published in this country, for 1806, mentioned the duration as 3 minutes.

7. The path of the spectator, I, II, III, IV, &c., calculated for the proposed latitude 42° 33′ 30″, may be made to answer for any other latitude by altering the centre of projection and the scale of equal parts. By this means the trouble of repeatedly describing that path, when the eclipse is to be calculated for several places, may be avoided. To do this, add the prop. log. of the reduced parallax to the log. secant of the latitude of the place; the sum, rejecting 10 in the index, will be the prop. log. of an arc A. To this prop. log. add the log. secant of the sun's declination (or star's in an occultation), and the log. cotangent of the latitude of the place; the sum, rejecting 20 in the index, will be the prop. log. of the arc B. Take the radius r VI (or qD), in the compasses, and make it a transverse distance on the line of lines of the sector corresponding to the arc A, and with that opening of the sector measure the transverse distance corresponding to the arc B, which, set from r towards C on the line rC (continued if necessary), will reach to the centre of the projection corresponding to the proposed latitude; the transverse distance corresponding to the reduced parallax, measured from the line of lines with the same opening, will be the radius of the projection, and the transverse distance corresponding to the horary motion of the moon from the sun or star, in an occultation, will be the horary distance to be made use of in marking the hours on the lunar orbit LN; lastly, the latitude of the moon at the conjunction is to be measured as a transverse distance, and set from the new centre of projection on a line drawn through it parallel to CR, and the point where it reaches will be the new point G, corresponding to the place of the moon at the ecliptic conjunction. Through this point the line of the moon's path is to be drawn parallel to the line LN of the figure, and the hours are to be marked on it as before. Whence the times of beginning and end of the eclipse may be found as in the above rule. An example of this method is not given, as it would render the scheme too confused.

PROBLEM XII.

To project an occultation of a fixed star by the moon, at any given place.

The method of projecting an occultation is nearly the same as that of an eclipse of the sun but to save the trouble of reference, it was thought expedient to give the rule without abridgment.

RULE.

To the time of the ecliptic conjunction of the moon and star, computed from the Nautical Almanac by Problem III., add the longitude of the proposed place turned into time, if east, but subtract if west; the sum or difference will be the time of conjunction at the proposed place. Corresponding to the time of conjunction at Greenwich, find, by Problem I., the moon's latitude, horizontal parallax, and semi-diameter: also the sun's right ascension. Then, by Problem II., find the horary motion of the moon in longitude and latitude, and by Tables VIII. and XXXVII., the star's right ascension, declination, longitude and latitude *

* In strictness, these quantities ought to be corrected for aberration and nutation, by Tables XXXIX. XLIII., but the correction is so small that it may always be neglected. If the right ascension and declination only are given, the latitude and longitude may be found by Problem XIX., and if the latter are given, the former may be calculated by Problem XX. It will be found most convenient to use the right ascensions and declinations which are given in the Nautical Almanac, when any of the stars marked in it are used

Digitized by Google

Draw the line ACB (Plate XIV. fig. 8), representing a parallel of the ecliptic passing through the star, and perpendicular thereto the line CPR. Take a scale of equal parts to measure the lines of projection, and from it take an interval equal to the difference of the latitudes of the moon and star, and apply it to the line CR from C to G, *above* the line ACB if the moon's latitude is north of the star's, otherwise *below*.* Take CO equal to the horary motion of the moon in longitude, and set it on the line CB to the right hand of C to O; take CP equal to the moon's horary motion in latitude, found with its sign by Problem II., and set it on the line CR from C to P, *above* † the line ACB if its sign is —, below if +. Join OP, which represents the horary motion of the moon in her orbit, and parallel to that line draw the orbit of the moon, NGL, on which are to be marked the places of the moon before and after the conjunction by means of the horary motion OP, so that the moment of the ecliptic conjunction at the proposed place may fall exactly at the point G, as in the figure where the conjunction is at 18h. 42m. This may be done by making OP equal to the transverse distance 60, 60, on the line of lines of the sector, then measuring from the same lines the transverse distance corresponding to the minutes and parts of a minute in the time of the ecliptic conjunction at the place of observation, and setting it on the line GN from G towards the right to the point *x*, the place of the moon at the first whole hour ‡ preceding the conjunction (which in the present figure is 18h.) Then the distance OP, being taken in the compasses, and set from *x* to the right hand, gives successively the preceding hours, and the same distance set to the left gives the following hours, as in the figure, where they are marked 17h., 18h., 19h., 20h. These hours are to be divided into 60 equal parts representing minutes, the scale being taken sufficiently large for that purpose.§ In the present figure the subdivisions are carried only to five minutes. Take the moon's horizontal parallax from the scale of equal parts for the radius CB, with which, on the centre C, describe the circle BRA, cutting CR in R. Open the sector till the transverse distance 60°, 60°, on the line of chords is equal to the radius CB, and measure from that line the transverse distance 23° 28' (equal to the obliquity of the ecliptic), which set on the circle ARB, on each side of R to T and U. Join TU cutting CR in Q. On Q as a centre, with the radius QT, describe a circle, TYUV, on which set off the arc TYV, equal to the star's longitude. Through V draw the line VP' parallel to CR. Open the sector till the transverse distance 90°, 90°, on the sines, is equal to the radius CB; then take in the compasses from the same lines an extent equal to the transverse distance corresponding to the complement of the declination of the star, and with one foot in C sweep a small arc to cut the line VP' in P', the place of the pole of the earth.‖ Draw CP', and continue it on either side so as to cut the circle ARB in the point W, situated *above* AB, if the latitude of the proposed place is *north*, but below if south. In the proposed figure the latitude is north. (If it had been south, the lower part of the circle ARB ought to have been made use of.) Open the sector as before, so as to make the transverse distance of 60°, 60°, on the chords, equal to CB, and take the chord of the complement of the latitude of the place, which set from W on each side to D and *d*. With the same opening of the sector measure the chord of the star's declination, which set on the circle ARB from the point D on each side, to E and F, and from *d* on each side to *e* and *f*. Draw the dotted lines F*f*, D*d*, E*e*, cutting CW in *l*, *q*, *n*. Bisect *l n* in *r*, and erect the line *t r u* perpendicular to CW, and make *r t*, *r u*, each equal to *q*D. Open the sector to make the transverse distance 90°, 90°, on the sines equal to *r t*, and on each side of *r* mark on the line *t r u* the sines of 15°, 30°, 45°, 60°, 75° (equal to 1h., 2h., 3h., 4h., 5h., respectively) to that radius, and mark the points with those degrees as in the figure; through these points draw the dotted lines parallel to *ln* as in the figure. Open the sector so that the radius *r l* may correspond to the transverse distance 90°, 90°, on the sines, and measure the complements of the former degrees as transverse distances on the sines, viz. 75°, 60°, 45°, 30°, 15°, and set them on the above dotted lines, on each side of the points 15°, 30°, &c., respectively, above and below the line *t r u*. A regular curve, *n t l u n*, drawn through the extremities of these dotted lines, will represent the path of the spectator in the given latitude. Subtract the sun's right ascension from the star's (increasing the latter by 24 hours when necessary); the remainder will be the hour of the star's passing the meridian,¶ which is to be marked at the upper point *l* of the path if the star's declination is south, but at the lower point *n* if the declination is north. The other hours are to be marked from this point towards the left, by marking successively, at the points where the dotted lines meet the path, the hour of the star's passing the meridian, increased by 1h., 2h., 3h., &c., completely round the curve, observing to reject 24 hours when the sum exceeds 24h. In the present example, the star's declination is south; consequently the upper point *l* of the path is taken for the hour of passing the meridian, 19h. 54m.; the extremities of the dotted lines to the left being marked successively 20h. 54m., 21h. 54m., 22h. 54m., 23h. 54m., 0h. 54m., &c.

* In the figure the point G is placed above ACB, because the moon is in a less southern latitude than the star. This part of the rule may also be thus expressed:—Find the moon's latitude with its sign as in Problem II. Prefix the sign + to the star's latitude if north, the sign — if south. Add the latitudes, noticing the signs as in algebra, and the distance CG will be obtained. If its sign is —, the point G is to be placed above C, but below C if the sign is +.

† See note with the mark * in page 473.

‡ See note with the mark † in page 473.

§ See note with the mark † in page 475.

‖ The distance of the line WV from the line CR, the situation of the point P', and the path of the spectator, may be found as in the note ‡ page 475.

¶ Or rather the horary distance of the sun and star at the time of the ecliptic conjunction of the moon and star

Digitized by Google

The path touches the circle ARB in two points, representing the points of rising and setting of the star, which, in the present figure, are 14h. 9m., and 1h. 39m. These points divide the path into two parts, of which one represents the path while the star is above the horizon, the other when below, as is evident from the hours marked on the curve. The half hours, or any other intermediate time, may be marked in a similar manner. Thus, for the time 4h. 24m., which is 3h. 30m., or 52° 30′, from the time 7h. 54m., marked at the point *n*, set the sine of 52½° to the radius *rt* from *r* to *h* on the line *rt*, and erect the perpendicular *hi*, equal to the sine of 37½° (which is the complement of 52½°), to the radius *rn*, and the point *i* will represent the place of the spectator at the proposed time. In this way the halves and quarters of hours may be marked on those parts of the path where necessary. The smaller subdivisions may generally be obtained to a sufficient degree of exactness by dividing the quarters of hours into equal parts.

Take from the scale of equal parts an extent equal to the semi-diameter of the moon, and beginning at the line NL, towards N, find, by trials, the point p' of the moon's path, and the point Z' of the path of the spectator, marked with the same time and at that distance apart. That time will be the beginning of the occultation or immersion at the proposed place. Proceed in the same way towards the point L, and find the points p, Z, at the same distance apart; the corresponding time will be the end of the occultation or emersion. About the points p', p, as centres, with a radius equal to the moon's semi-diameter, describe the small circles meeting the paths of the spectator in the points Z', Z. These circles will represent the moon's disc; the points Z', Z, the places of the star, and the line CZ', CZ, the vertical circles passing through the star at the times of immersion and emersion respectively. To render this part of the scheme more distinct to the eye, it is drawn separately in figure 9, Plate XIV., in which the points C, p', Z', are similarly situated to the corresponding points of figure 8, marked with the same letters. Through p' draw the line $a'p'c'$ parallel to CZ, to meet the moon's disc in a', c'. Then the circle $a'Z'c'$, being held between the eye of the observer and the sun, the engraved or marked side of the figure towards the eye, and the line CZ' (or $a'p'c'$) in a vertical position with the point Z' above C, will represent the appearance of the moon and star as viewed by the naked eye; c' will represent the upper part of the moon, a' the lower part, and Z' the point of contact. The contrary will be observed if the object be viewed by an inverting telescope. It will generally be conducive to the accuracy of an observation, to estimate in this manner the point of emersion, so as to keep that point of the moon's limb in the field of view of the telescope, and the eye directed towards that point of the limb, so as to perceive the star at the first instant of its appearance. The situation of the point of emersion with respect to the horns ϱ, θ, of the moon may also be made use of for this purpose. The line $\varrho p \theta$, connecting the moon's horns, is nearly parallel to the line CR, except very near the new or full moon; so that in general it will be sufficiently correct to draw through p the line $\varrho p \theta$ parallel to CR. If greater accuracy is required, the following construction may be made use of. Subtract the sun's longitude from the moon's,† make the arc TYUλ equal to the remainder, and join Qλ. Set on the same circle the arc Tβ equal to the moon's latitude; *below* the point T if that latitude is *south*, *above* if *north*. Through β draw the line $\beta \varepsilon \delta$ parallel to TQ to cut Qλ in ε and CR in δ. Take the extent QT and set it on the line δY above δ to μ. Join $\mu \varepsilon$, and parallel thereto through p draw the line $\varrho p \theta$ cutting the moon's disc in the points ϱ θ representing the horns, the figure being viewed as above directed. The enlightened part of the moon is that nearest to the sun; the dark part is the most distant from it.

EXAMPLE.

Required the times of immersion and emersion of Spica, December 12, 1808, at a place in the latitude of 20° N., and in the longitude of 1h. 9m. east from Greenwich.

By the first page of the Nautical Almanac for the month of December, 1808, the time of the ecliptic conjunction of the moon and Spica (marked ☽ *a* ♍) was December 12, 17h. 33m at Greenwich, corresponding to 18h. 42m. at the proposed place. This time may also be computed by means of the longitudes of the objects, as in Problem III. of this Appendix. At the time at Greenwich, 17h. 33m., the elements of the occultation were, as in the adjoined table, calculated by the above rule.

ELEMENTS.	h. m. s.
Conjunction at Greenwich, Dec. 12, 1808.......	17 33 00
Longitude east from do..........................	1 09 00
Conjunction at place of observation...........	18 42 00
✱'s right ascension, Table VIII.	13 15 08
☉'s right ascen. by Nautical Almanac..subtract	17 21 18
✱ passes the meridian	19 53 50
Latitude of the place..............................	20° 0′ 0″
☽'s horizontal paral. by Nautical Almanac..CB	59 55.2
☽'s semi diameter by Nautical Almanac	16 19.8
☽'s horary motion in longitude, Prob. II....CO	35 55.2
☽'s horary motion in latitude, Prob. II......CP	— 3 02.7
✱'s longitude, Table XXXVII. ....TYV	201 10 31
☽'s latitude by Nautical Almanac...............	1 49 53 S.
✱'s latitude, Table XXXVII.......................	2 2 13 S.
Difference of latitudes ☽ N. of ✱...........CG	12 20 N.
✱'s declination	10 10 S.

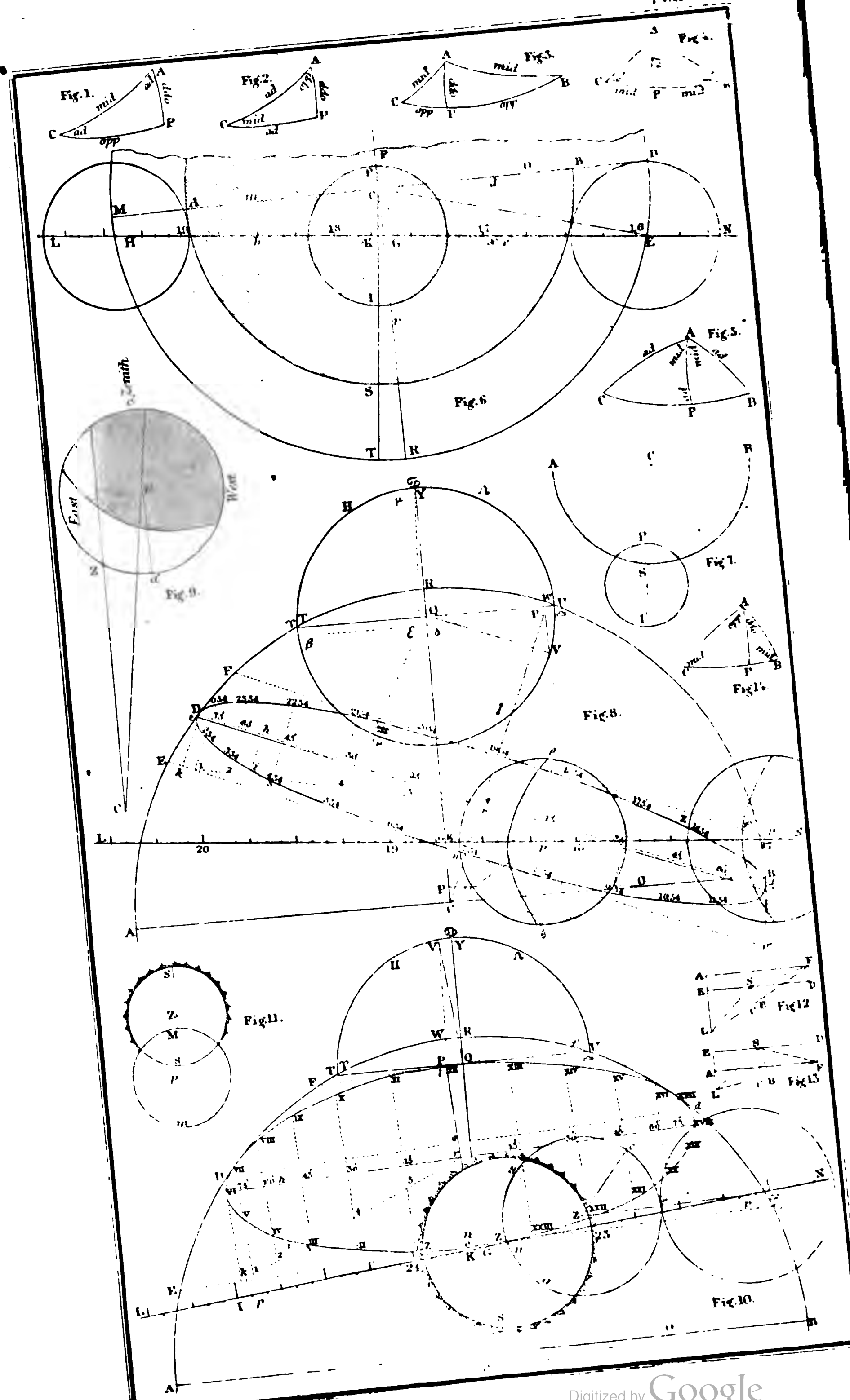
Draw ACB, and perpendicular thereto the line CGY. Make CG equal to the difference between the

† In strictness, the longitude and latitude of the moon at the time of immersion or emersion ought to be made use of; but it will be sufficiently exact to use the star's longitude instead of the moon's (increasing it by 360° when less than the sun's longitude), and the moon's latitude at the conjunction. Quantities of the same order as the moon's parallax are neglected in the value of the arc TYUλ.

Digitized by Google

Digitized by Google

Plate XIV



Digitized by Google

latitudes of the moon and star, 12′ 20″, taken from a scale of equal parts, the point G being above C, because the moon is northward of the star. Make CO equal to the moon's horary motion in longitude, 35′ 55″.2, to the right of C; and CP equal to the horary motion in latitude, —3′ 2″.7, the point P being above C because the sign is — (or the latitude is south decreasing). Draw NGL parallel to OP. Make OP a transverse distance of 60, 60, on the line of lines of the sector, and measure from the same lines the transverse distance 42, 42 (corresponding to the minutes in the time of the conjunction); this distance set on the line GN, from G towards the right hand, reaches to the point x of the path where the hour preceding the conjunction is to be marked, viz. 18h. Take OP in the compasses, and mark it on the line LN, from x, or 18h., to the right to 17h., and to the left to 19h., 20h., &c. These are subdivided into five minutes, the scale not admitting of smaller divisions. Take the moon's parallax, 59′ 55″.2, from the scale of equal parts, and with that radius describe about the centre C the circle ARB. Set off (by means of the sector) the arcs RT, RU, each equal to 23° 28′. Join TQU, and about that diameter describe the circle TYUVT. Make the arc TYV equal to the star's longitude, 201° 10′ 31″, which is done by making the arc UV = 21° 10′ 31″. Draw P′V parallel to CR, and, with an extent equal to the complement of the star's declination, 79° 50′, taken as a transverse distance from the sines, with the radius CB, and with one foot in C, sweep an arc cutting P′V in P′. Join CP′ and continue it to meet the circle ARB in W. Set on each side of W the arcs WD, Wd, equal to the complement of the latitude of the place, 70°. Make the arcs DF, DE, df, de, each equal to the star's declination, 10° 10′, and draw the lines Flf, Dqd, Ene, cutting CW in l, q, n. Bisect ln in r, draw tru parallel to Dqd, and make rt, ru, equal to qD. Through the points l, t, n, u, l, draw the path of the spectator, as taught in the above rule, and mark the hour of the star's passing the meridian, 19h. 53m. 50s., or 19h. 54m., at the upper point l, because the star's declination is south. Mark the following hours in succession, 20h. 54m., 21h. 54m., &c., to the left, as in the figure. Take an extent in the compasses equal to the moon's semi-diameter, 16′ 19″.8, and, beginning towards N, find, as above directed, the points v', Z', at that distance apart, and marked with the same time, 16h. 57m., which is the time of the immersion. Proceed in the same way for the emersion corresponding to the points p, Z, at the same distance apart, and the time of the emersion, 18h. 10m., will be obtained. With the same extent describe about p and p' the small circles representing the disc of the moon at these times, and cutting the path of the spectator in the point Z, Z′. Join CZ′, Cp' and parallel to CZ′ draw $c'p'a'$ cutting the moon's disc in c', a' (as in fig. 9, Plate XIV.) and the arc $a'Z'$ will represent the distance of the point of immersion from the lower part a of the moon. The line CZ runs nearly through the point p, so that the top part of the moon c and the point Z nearly coincide; consequently the emersion happened near the moon's zenith. By subtracting the sun's longitude, 261° 7′, from the moon's or star's, 201° 10′ (increased by 360°), the remainder is 300° 3′, which is to be marked on the circle TYUV to the point λ. Make the arc Tβ equal to the moon's latitude, 1° 49′ 53″, taking the point β below T because the latitude is south. Draw the lines λQ, $\beta\epsilon\delta$, $\mu\epsilon$, $\varrho p\theta$, as in the rule, and the points ϱ, θ, will represent the places of the moon's horns. The point of emersion Z will be to the westward of the upper horn ϱ, about 60° measured on the moon's limb.

REMARKS.

1. When it is thought necessary to take notice of the spheroidal form of the earth, the corrections of latitude and parallax of Table XXXVIII. must be subtracted from the latitude of the place and the moon's horizontal parallax respectively, to obtain the latitude and parallax to be made use of in the above rule.

2. Subtract 2″ from the moon's semi-diameter given by the Nautical Almanac, if it be thought necessary; the remainder is to be made use of, *without augmentation*, on account of the altitude of the moon.

3. The corrections for the change of the moon's semi-diameter, horizontal parallax, and horary motion during the occultation, are neglected in the above rule, as not materially affecting the result.

4. The line CZ′ measured on the sines as a transverse distance to the radius CB, will be the star's zenith distance at the immersion. In a similar manner it may be found at the emersion at Z, or at any other point.

5. The curve $ltnu$ may be made to answer for any latitude, as in Problem XI., Remark 7

Calculation of an occultation of a planet by the moon.

By a similar process the times of immersion and emersion of a planet may be calculated by finding the planet's right ascension and declination, geocentric longitude and latitude, from the Nautical Almanac, and using them instead of the star's; also, by Problem II., the horary motion of the moon from the planet in longitude and latitude, which are to be used instead of the horary motion of the moon. In this projection it will not be necessary to take notice of the parallax of the planet, but it may be easily allowed for by taking the radius CB equal to the difference of the horizontal parallaxes of the moon and planet. The apparent diameter of the planet may also be neglected, making the distances pZ, p'Z′, equal to the moon's semi-diameter. When great accuracy is required, the sum of the semi-diameters of the moon and planet must be made use of for finding the external contacts, and their difference for the internal contacts.

Digitized by Google

PROBLEM XIII.

To calculate the beginning or end of a solar eclipse.

RULE.

This must be done by approximation, by assuming a time for the beginning or end of the eclipse, as, for example, the time obtained by projection by Problem XI., the time of new moon at the place of observation, or an hour before or after, according as it is the beginning or end of the eclipse that is sought. With this time calculate the elements of the eclipse and the parallaxes, as taught in the first part of Problem VIII. The parallaxes applied to the longitude and latitude of the moon by the Nautical Almanac, will give the apparent longitude and latitude. Find the difference of the apparent longitudes of the moon and sun, and from its proportional logarithm, increasing the index by 10, subtract the proportional logarithm of the moon's apparent latitude; the remainder will be the log. tangent of an angle, whose corresponding log. cosine is to be added to the proportional logarithm of the difference of longitudes; the sum, rejecting 10 in the index, will be the proportional logarithm of the apparent distance of the centres of the sun and moon, which ought to be equal to the sum of the corrected semi-diameters, if the assumed time was correct. If this is not the case, the operation must be repeated with an assumed time differing a few minutes from the former, and the apparent distance of the centres of the sun and moon must be calculated in this new supposition. Then add together the arithmetical complement of the proportional logarithm of the difference of the apparent distances thus calculated, the proportional logarithm of the difference between the first calculated distance and the sum of the semi-diameters, and the proportional logarithm of the interval of time between the two suppositions; the sum, rejecting 10 in the index, will be the proportional logarithm of the correction to be applied to the first assumed time, which, at the beginning of an eclipse, is to be *added* to the first assumed time, if the distance be *greater* than the sum of the semi-diameters, but *subtracted* if *less;* and the contrary in calculating the end of an eclipse; the sum or difference will be the *approximate* time of the beginning or end of the eclipse. If great accuracy is required, the operation may be repeated with this approximate time, combining this result with one of the former suppositions; and thus the operation may be repeated till the apparent distance of the centres at the assumed time is found to be exactly equal to the sum of the corrected semi-diameters.

REMARK.

This rule, with some modification, will answer for calculating the time of an occultation of a fixed star or planet by the moon. In this case, the star's longitude is to be found in Table XXXVII., and corrected for the equation, Table XLI.* (or the planet's longitude is to be taken from the Nautical Almanac;) the difference between this and the moon's apparent longitude corresponding to the assumed time being found, its proportional logarithm is to be added to the log. secant of the moon's apparent latitude, and the sum is to be used in finding the distance of the centres instead of the proportional logarithm of the difference of longitude of the sun and moon, with the index increased by 10. The latitude of the star is to be found by Tables XXXVII. and XLI., or the planet's latitude by the Nautical Almanac, and added to the latitude of the moon, if of a different name; otherwise their difference is to be taken and made use of, instead of the moon's latitude in the above rule. Lastly, instead of the sum of the semi-diameters, the semi-diameter of the moon is to be made use of. When very great accuracy is required in calculating an occultation of a planet by the moon, the difference of the parallaxes of the moon and planet, decreased by the correction of parallax, Table XXXVIII., is to be made use of as the reduced parallax, in finding the parallaxes in longitude and latitude. When the apparent distance of the centres of the moon and planet is equal to the sum of their semi-diameters, their limbs will just appear to touch each other; and when that distance is equal to the difference of the semi-diameters, the planet will be wholly covered by the moon.

EXAMPLE.

Required the time of the beginning of the solar eclipse of June, 1806, at Salem, supposing the errors of the moon's longitude and latitude in the Nautical Almanac to be unknown.

To abridge the present calculation, suppose the beginning of the eclipse to be June 15d. 22h. 6m. 18s.1, apparent time, the elements corresponding to which have been calculated in Problem VI.; namely, moon's apparent longitude, 84° 8′ 50″.3; moon's apparent latitude, 1′ 55″.8 N., these being corrected for the errors of the tables, 58″.5, and 11″.4; hence the uncorrected values are 84° 9′ 48″.8, and 2′ 7″.2 N. The difference between this apparent longitude of the moon, and the sun's longitude, 84° 41′ 3″.4, is 31′ 14″.6.

Difference of longitude... 31′ 14″.6......Prop. Log.	10.7605	....	0.7605
☽'s apparent latitude..... 2 7 .2......Prop. Log.	1.9289		
Tang.	8.8316	— Corresponding Cosine	9.9990
Apparent distance ☉ ☽....31 19″.0......Prop Log.			.7595

* We must also apply the correction of Table XL., if the longitudes are counted from the apparent equinox, as was the case formerly in the Nautical Almanacs

Digitized by Google

This apparent distance differs 1′ 4″.5 from the sum of the semi-diameters, 32′ 23″.5. It is therefore necessary to make a second supposition, as for example ten minutes later, or at 22h. 16m. 18s.1; with this time the elements are to be again calculated as in Problem VI., namely, moon's apparent longitude uncorrected, 84° 14′ 17″.1; sun's longitude, 84° 41′ 27″.2, their difference, 27′ 10″.1; moon's apparent latitude uncorrected for error of tables, 1′ 58″.8 N

Difference of longitude...	27′ 10″.1....	Prop. Log. 10.8212	0.8212
☽'s apparent latitude.....	1 58 .8.....	Prop. Log. 1.9586	
		Tang. 8.8626....Corresponding Cosine	9.9988
Second apparent distance ☉ ☽	27′ 14″.7	Prop. Log.	.8200
First apparent distance ☉ ☽	31 19 .0		
Difference	4 4 .3	..Arith. Comp Prop. Log.	8.3545
Difference first distance and semi-diameters	1 4 .5	Prop. Log.	2.2238
Interval	10 0	Prop. Log.	1.2553
Correction	2 38	Prop. Log.	1.8336
First supposed time	15d. 22h. 6m. 18s.1		
Approximate time	15d. 22h. 3m. 40s.1		

If the approximate time differ very much from the assumed times, it will be necessary to repeat the operation till the last assumed and calculated times agree.

PROBLEM XIV.

Given the moon's true longitude to find the mean time at Greenwich.

RULE.

1. Take from the Nautical Almanac the two longitudes immediately preceding the given longitude and the two following, and find the first and second differences, as in Problem I. Call the middle term of the first differences the arc A, and the half-sum of the second differences, (noticing the signs,) the arc B.

2. To the constant logarithm 4.63548 add the arithmetical complement of the logarithm of A, in seconds, and the logarithm of the difference in seconds between the given longitude and the second longitude, taken from the Nautical Almanac; the sum, rejecting 10 in the index, will be the logarithm of the *approximate* time T in seconds.

3. Enter Table XLV. with the arc B at the top, and this time T at the side, and find the corresponding correction; to the logarithm of which add the two first logarithms above found; the sum, rejecting 10 in the index, will be the *correction* of the approximate time, to be applied with the *same* sign as the arc B, and the correct mean time, counted on from the second noon or midnight, will be obtained

EXAMPLE

Suppose the moon's longitude, July 12, 1836, was 98° 10′ 16″.0. Required the corresponding mean time at Greenwich.

Mean time. d. h.	☽'s longitudes. ° ′ ″	1st difference. ° ′ ″	2d difference. ″
July 11 12	89 12 57.4		
12 0	95 07 44.7	5 54 47.3	
12 12	101 03 20.9	A = 5 55 36.2	+ 48.9
13 0	106 59 59.8	5 56 38.9	+ 62.7
			B = + 55.8

☽'s longitude	98° 10′ 16″.0
July 12d. 0h......	95 07 44 .7
Diff. longitude....	3 02 31 .3 = 10951″.3

		Constant Log.	4.63548
A	= 21336″.2	Arith. Comp. Log.	5.67089
Diff. of long......	10951″.3	Log.	4.03946
Approx. time..	6h. 09m. 33s. = 22173s	Log.	4.34583
Correction	+ 14		
Mean time....	6h. 09m. 47s. past noon, July 12d.		

....	4.63548
....	5.67089
Eq. Tab. XLV. + 7″.0.......Log.	0.84510
Correction, + 14s. ....Log.	1.15147

The same method might be used in finding the time from the moon's right ascension, supposing the Nautical Almanacs to give the right ascensions at noon and midnight only, as was formerly the case; but as they are now given for every hour, we may obtain the time much more simply by the following rule:—

RULE.

Take from the Nautical Almanac the right ascensions of the moon which immediately precede and follow the time at Greenwich, of the proposed observation. Take the difference, D, of those two right ascensions, in seconds of time, also the difference, d, in seconds of time, between the given right ascension and that corresponding to the first hour. Then to the constant logarithm 3.55630 add the arithmetical complement of the logarithm of D and the logarithm of d; the sum, rejecting 10 in the index, will be the logarithm of a number of seconds to be added to the hour first marked in the Nautical Almanac, to obtain the mean time of the observation at Greenwich, nearly

Digitized by Google

EXAMPLE.

The moon's right ascension, July 12, 1836, was, by observation, 6h. 36m. 39s.35. Required the mean time of observation.

		Right Ascension.	Difference		
				Constant Log.	3.55630
July 12d.	........Observed right ascension,	6h. 36m. 39s.35	d = 21s.69	..................Log.	1.33626
July 12d. 6h.	........................by N. A.	6 36 17 .66	D = 133 .04	.....Arith. Comp. Log.	7.87602
July 12d. 7h.	........................by N. A.	6 38 30 .70			
			9m. 47s. = 587s.	.... Log	2.76858
First hour	....	12d. 6h. 0 0			
Mean time of observation, July		12d. 6h. 9m. 47s.			

PROBLEM XV.

Given the distance of the moon from a fixed star not marked in the Nautical Almanac, together with the altitudes of the objects, the mean time of observation, and the estimated longitude, to find the longitude of the place of observation.

First solution, using the latitudes and longitudes of the moon and star

RULE.

To the mean time of observation, by astronomical computation, add the estimated longitude in time if west, or subtract if east; the sum or difference will be the supposed mean time at Greenwich,* corresponding to which, find the moon's latitude, by Problem I., also the longitude and latitude of the star, by Table XXXVII., and correct them for aberration, by Table XLI.

With the apparent altitudes and distance of the objects, find the *correct* distance by the usual rules of working a lunar observation.

To the correct distance, add the latitudes of the moon and star, and find the *difference* between the *half-sum* and the distance. Then to the log. secants of the latitudes of the moon and star, rejecting 10 in each index, add the log. *cosines* of the half-sum and difference, if the latitudes are of the *same* name, or the log. *sines*, if of a *contrary* name; half the sum of these four logarithms will be the log. *cosine* of half the difference of longitude, if the latitudes are of the *same* name, or its log. *sine*, if of a *different* name.

The difference of longitude is to be added to the apparent longitude of the star, if the moon is east of the star, otherwise subtracted, (borrowing or rejecting 360° when necessary;) the sum or difference will be the true longitude of the moon; whence the mean time at Greenwich may be found, by Problem XIV. The difference between this and the mean time at the ship, will be the longitude, which will be *west*, if the mean time at Greenwich be greater than the mean time at the ship, otherwise *east*.

REMARK.

This method, with a slight modification, can be used in finding the longitude from the observed distance of the moon from a planet, as Jupiter, Venus, Mars, or Saturn, in cases where they are not marked in the Nautical Almanac. The only difference in the rule, when a planet is used instead of a star, consists in finding from the Nautical Almanac, by Problem I., the geocentric longitude and latitude of the planet, which are to be used instead of the longitude and latitude of the star in the above rule. For the daily variation of the longitude and latitude of a planet is so small, that no error of moment can arise from calculating those quantities for the *supposed* instead of the *true time* at Greenwich; and the parallax and semi-diameter of the planet can be allowed for by the methods pointed out in working a lunar observation.

The latitudes of the moon and the fixed star or planet, made use of in these observations ought not to differ very much, on account of the decrease of the relative motion arising from this source. If the latitudes are of a different name, their sum, otherwise their difference, ought to be found, and if it does not exceed one third part of the difference of longitude of the two objects, they may in general be made use of.

EXAMPLE.

Suppose that, on the 7th of January, 1836, sea account, at 11m. 57s. past midnight, mean time, in the longitude of 127° 30′ E., by account, the observed distance of the farthest limb of the moon from the star Aldebaran, was 68° 36′ 0″, the observed altitude of the star 32° 14′, and the observed altitude of the moon's lower limb 34° 43′. Required the true longitude, without using the distances marked in the Nautical Almanac, upon the supposition that they are not given in it.

This lunar observation has already been computed by the common methods, in page 232, where we have found that the supposed time at Greenwich is Jan. 6d. 3h. 41m. 57s., the moon's semi-diameter 15′ 15″, the moon's horizontal parallax 55′ 24″, the star's apparent altitude 32° 10′, the moon's apparent altitude 34° 55′, the apparent distance of the centres of

* This time may also be obtained from the chronometer, if you have one which is pretty well regulated to astronomical time

Digitized by Google

the moon and star 68° 20′ 45″. With these we find the true distance of the centres of the moon and star, by the usual rules for working a lunar observation, to be 68° 3′ 0″, as in page 232. The moon's latitude, deduced from the Nautical Almanac, by Problem I., is 4° 59′ 10″ N. Then the star's longitude and latitude are found as below, by Tables XXXVII., XLI., making use of the sun's longitude, 285° 17′, as given in the Nautical Almanac, these longitudes being counted from the mean equinox; with these elements the calculation is made in the following manner:—

Table XXXVII.	✱'s longitude, Jan. 6, 1836	67° 29′ 47″.1	✱'s latitude	5° 28′ 3[illegible]″.0 S.
Table XLI.	Aberration	+ 15 .9	Aberration	+ 1 .2
	✱'s apparent longitude	67 30 03	✱'s apparent latitude	5 28 40 .0 S.

True distance	68° 03′ 00″		
☽'s latitude	4 59 10 N.	Secant	0.00164
✱'s latitude	5 28 40 S	Secant	0 00199
Sum	78 30 50		
Half-sum	39 15 25	*Sine* *	9.80126
Difference of half-sum and distance	28 47 35	*Sine* *	9.68274
		2)	19.48763
Half-difference of longitude	33 40 06	*Sine* *	9.74381
Difference of longitude	67 20 12		
✱'s longitude	67 30 03		
☽'s longitude	134 50 15		
☽'s longitude, Jan. 6d. 0h.	132 54 51		
Difference	1 55 24 = 6924″ = difference.		

	d.	h.		1st differences ° ′ ″	2d differences ″
☽'s longitude...Jan.	5	12	126 41 37.6		
	6	0	132 54 51.1	6 13 13.5	
	6	12	139 10 47.8	A = 6 15 56.7	+2 43.2
	7	0	145 29 34.2	6 18 46.4	+2 49.7
					Mean = +2 46.5

	Constant Log.	4.63548		4 63548
A = 6° 15′ 56″.7 = 22556″.7	Log. Ar. Co.	5.64672		5.64672
Difference, 6924″	Log.	3.84036	Equation, XLV. + 17″.6 Log.	1.24551
Approx. time, 3h. 41m. 01s. = 13261s.	Log.	4.12256	Correction ..... + 34s. Log	1.52771
Correction... + 34				
Time........ 3h. 41m. 35s.				

Hence time at Greenwich, Jan. 6d.	3h.	41m.	35s	
Mean time at the ship, Jan. 6	12	11	57	
Longitude	8h.	30m.	22s.	= 127° 35′ 30″ E. from Greenwich, differing 5′ 15″ from the calculation in page 232.

The computed time at Greenwich, 3h. 41m. 35s., differs from the assumed time, 3h. 41m. 57s., only 22s.; and, during this interval, the moon's latitude varies so little, that it will not be necessary to repeat the operation on account of this variation; observing that an error of one minute in the moon's latitude affects the secant of the latitude about 0.00001, and this produces in the difference of the longitude an error of only 2″ or 3″ in the present example; and as the latitudes are always small, it will hardly ever be necessary to repeat the operation when this method is used.

Second solution, using the right ascensions of the moon and star.

RULE.

To the mean time of observation, by astronomical calculation, add the estimated longitude in time if west, or subtract if east; the sum or difference will be the supposed mean time at Greenwich. This time may also be taken from the chronometer, if you have one which is pretty well regulated for mean time at Greenwich. With this time, enter the Nautical Almanac, and find from it the right ascension and declination of the star or planet, and the declination of the moon.

With the apparent altitudes and distances of the objects, find the correct distance by the usual rules of working a lunar observation.

To the correct distance add the declinations of the moon and star, and find the *difference* between the *half-sum* and the distance. Then to the log. secants of the declinations of the moon and star, rejecting 10 in each index, add the log. *cosines* of the half-sum and of the difference, if the declinations are of the *same* name, or the log. *sines*, if of a *contrary* name; half the sum of these four logarithms is to be sought for in the column of log. *cosines*, if the declinations are of the *same* name, or in the column of log. *sines*, if of *different* names; and

* Use *cosine* if the latitudes are of the same name

Digitized by Google

the corresponding time in the *column* P. M. is the difference of the right ascensions of the moon and star.

This difference of right ascension is to be added to the apparent right ascension of the star, if the moon is east of the star, otherwise subtracted, (borrowing or rejecting 24h. when necessary ;) the sum or difference will be the true right ascension of the moon's limb.

If the moon's true right ascension can be found exactly in the Nautical Almanac, the corresponding hour will be the mean time at Greenwich. If it cannot be found exactly, as will most commonly happen, take out the right ascensions for the hours immediately preceding and following, and note their difference, D, in seconds of time; take also the difference, d, in seconds of time, between the moon's true right ascension and that right ascension marked for the first hour in the Nautical Almanac. Then, to the constant log. 3.55630, add the arithmetical complement of the logarithm of D, and the logarithm of d; the sum, rejecting 10 in the index, will be the logarithm of a number of seconds, to be added to the hour first marked in the Nautical Almanac, to obtain the mean time of the observation at Greenwich. The difference between this and the mean time at the ship, will be the longitude, which will be *west*, if the mean time at Greenwich be greater than the mean time at the ship, otherwise *east*.

We may observe, that we can, as in the first solution, use a planet instead of a star.

We shall now calculate, by this method, the same example as in the first solution. In this case, for the supposed time at Greenwich, January 6d. 3h. 41m. 57s., we find, by means of the Nautical Almanac, Aldebaran's right ascension 4h. 26m. 31s.3, Aldebaran's declination 16° 10′ 29″ N., and the moon's declination 21° 9′ 33″ N.

True distance, as in page 232......	68°	03′	00″			
☽'s declination........................	21	09	33	N.	Secant	0.03032
✱'s declination........................	16	10	29	N.	Secant	0.01754
Sum..................................	105	23	02			
Half-sum	52	41	31	....	*Cosine* *	9.78254
Difference of half-sum and distance	15	21	29	....	*Cosine* *	9.98420
					2)	19.81460
Difference of ✱ and ☽'s right ascensions	4h.	48m.	56s.9	....	*Cosine* *	9.90730
✱'s right ascension........................	4	26	31 .3			
					Constant Log.	3.55630
☽'s right ascension........................	9	15	28 .2	Difference d = 88s.4..............	Log.	1.94645
By N. A. ☽'s right ascension, Jan. 6d. 3h.	9	13	59 .8	Difference D = 128 .3..Arith. Comp.	Log.	7.89177
Jan. 6d. 4h.	9	16	08 .1			
		41m.	20s.	= 2480s................	Log.	3.39452
Add	3h.	00	00			
Time at Greenwich..........................	3	41	20			
Time at the ship............................	12	11	57			
Longitude	8	30	37	= 127° 39′ 15′ E from Greenwich		

differing 1′ 30″ from the calculation in page 232.

PROBLEM XVI.

Given the intervals of time between the passages of the moon's bright limb and a fixed star over two different meridians, to find the difference of longitude between the two meridians.

This problem includes, also, the case where one of the observations is supposed to be made at Greenwich, considering the time of the transit of the moon's bright limb over that meridian, given in the Nautical Almanac, as an actual observation; the error arising from this supposition being very small, on account of the great degree of accuracy of the lunar tables used in the computation of the Nautical Almanac. We may, however, observe that, where good observations can be obtained at both meridians, it is always best to use them in preference to the computed transits in the Nautical Almanac.

The principle upon which the longitude is found in this method is similar to that which is used in a common *lunar observation*, and depends on the observed motion of the moon; but, in the present problem, this motion is ascertained by observing the time when the moon's bright limb passes the meridian, instead of measuring the angular distance of the moon from the sun or a star. The variation of the moon's right ascension, corresponding to a change of 15° in the longitude, is given very accurately by the Nautical Almanac for every transit of the moon's limb at Greenwich. This variation is about 2m. in time for 1h. of longitude, and when the difference of the times of transit under different meridians has been found by observation, it is easy to get, by proportion, the corresponding longitude, as we shall see in the following examples

This method of computing the longitude is very much facilitated by the new table of moon-culminating stars, inserted in pages 410—451 of the Nautical Almanac. To show the construction of the table, we shall insert the following extracts from it, contained in page 438 of the Nautical Almanac for 1836

* Use *sine* if the declinations are of different names

Digitized by Google

Col. 1.	Col. 2.	Col. 3.	Col. 4.	Col. 5.	Col. 6.	Col. 7
1836.	Name.	Magnitude.	App. R. Ascens. in time.	Declination.	Var. ☽'s Right Ascension in 1h. of long.	Sid. Time ☽'s semi-diameter pass. merid.
			h. m. s.	° ′	s.	s.
Sept. 15	Moon I u. c.	(4.6)	15 07 52.16	18 25 S.	140.92	69.80
15	Moon I. l. c.		15 36 34.71	20 50 S.	146.22	71.16
16	Moon I. u c.	(5.6)	16 06 21.71	22 57 S.	151.02	72.52
16	Moon I. l. c		16 37 12.45	24 42 S.	156.77	73.79
17	Moon I. u c.	(6.7)	17 09 01.65	26 04 S.	161.29	74.88
17	Moon I. l. c.		17 41 39.15	27 00 S.	164.75	75.69
16	α Scorpii	1	16 19 23.07	26 04 S.		
16	τ Scorpii.	3.4	16 25 42.46	27 52 S.		
17	α Scorpii.	1	16 19 23.05	26 04 S.		

The stars whose right ascensions and declinations are inserted in this table, are called moon-culminating stars, because they have nearly the same declination as the moon, and do not differ much in right ascension, so that they are conveniently situated for observations of the differences of the times of the transit which are required in this problem. The first column of this table contains the date; the second, the name of the star or moon. If the bright limb of the moon be the first which passes the meridian, it is marked I.; but if it be the second limb, it is marked II. The upper culmination of the moon is marked u. c.; the lower culmination, *l. c.*; this last being of frequent use in high latitudes. The third column contains the magnitudes of the objects; that of the moon being denoted by her age, expressed in days and tenths of a day. The fourth column contains the apparent right ascension of the moon's bright limb, at the time of the transit over the meridian of Greenwich; and the fifth column, its declination at that time: the same columns contain also the right ascensions and declinations of the moon-culminating stars at their upper culmination. The sixth column contains the variations in the right ascension of the moon's bright limb during the intervals of her transit over two meridians; one of these meridians being 7° 30′ W. from Greenwich, and the other 7° 30 E. from Greenwich; so that the distance of these two meridians is 15°, or 1h. in longitude. For convenience of reference, we shall call this variation the arc H, supposing it to be expressed in seconds of time, as in column 6.

The arcs H, in the sixth column, are deduced from the right ascensions of the moon's bright limb, contained in the fourth column, so that they include the effect produced by the changes of the moon's semi-diameter. The seventh column contains the intervals of the transit of the moon's semi-diameter over the meridian expressed in sideral time; this time being generally used in making such observations, and for this purpose it is usual to note the times of transit by a clock regulated to sideral time. If the intervals are given in mean time, they may be reduced to sideral time by adding the correction in Table LI. corresponding to that time. Thus, if the interval is 6h. mean time, the tabular correction in column 1 of that table is 59s.1, making the interval 6h. 0m. 59s.1, sideral time. If the interval be 6h. 58m. mean time, the corrections in Table LI., columns 1, 2, are 59s.1 + 9s.5 = 1m. 8s.6; consequently the interval in sideral time is 6h. 59m. 8s.6.

The numbers in columns 4, 5, 6, 7. of the table of moon-culminating stars, correspond to the meridian of Greenwich, and may be reduced to any other meridian by the usual method of interpolation, as in Problem I., page 396. Thus, from the above extracts from this table, it appears that, at the time of the upper culmination, September 16, 1836, the right ascension of the moon's bright limb was 16h. 06m. 21s.71. At the following lower culmination, it was 16h. 37m. 12s.45, which may be considered as corresponding to the upper culmination, September 16, in a place 12h. in longitude west from Greenwich; and at the next upper culmination, the right ascension was 17h. 09m. 01s.65, which may be considered as appertaining to September 16, in a place 24h. west from Greenwich; according to the ancient method of counting the longitude, in a westerly direction completely round the globe. In like manner, in east longitude, we have, at the upper culmination at Greenwich, September 16, 1836, the right ascension of the moon's bright limb 16h. 06m. 21s.71, and we may suppose the preceding transit, 15h. 36m. 34s.71, to correspond to the longitude 12h. east, and so on.

This being premised, we shall now proceed to show how to find, by interpolation, the moon's right ascension at the time of her transit over any meridian in east or west longitude from Greenwich. The process of calculation is very nearly the same as that in Problem I., page 396, but for convenience we have reduced it to the following form:—

RULE.

To find the moon's right ascension at her transit over any meridian.

1. Take from the fourth column of the table of moon-culminating stars, the right ascensions of the same limb of the moon corresponding to four successive culminations,* so that

* Near the time of full moon, when the limb marked in the table changes from I. to II., there may be one or two of these quantities not marked in column 4th of the table for the limb which is wanted in the calculation. In this case, the required quantities can be obtained from the corresponding tabular numbers, by

Digitized by Google

two may precede and two follow after the time of transit at the proposed place. Put these numbers below each other in their regular order; then find their first and second differences. Call the middle term of the first differences, the arc A; the mean of the 2nd differences, the arc B; and if the longitude be west from Greenwich, put T equal to that longitude in time; but if the longitude be east, put T equal to the difference between 12h. and that longitude.

2. To the constant logarithm 5.36452 add the logarithm of T in seconds of time, and the logarithm of A in seconds of time; the sum, rejecting 10 in the index, will be a *proportional part*, which is to be added to the second right ascension taken from the Nautical Almanac.

3. Enter Table XLV. with the arc B at the top, and the time T at the side; opposite to this will be the correction of second differences, to which prefix a *different sign* from that of the arc B, and place it under the second ascension and the proportional part above found. Connect these three quantities together, as in addition in algebra; the sum will be the sought right ascension of the moon at the time of her transit over the proposed meridian.

The same process may be used for interpolating the numbers in columns 5, 6, 7, as we shall see in the following examples:—

EXAMPLE 1.

Required the right ascension of the moon, September 16, 1836, astronomical account, at the time of the transit over the meridian of a place whose longitude is 3h. 48m. 29s. west from Greenwich; also, the value of the arc H, deduced from the numbers in column 6, for the time of this transit.

Here we have T=3h. 48m. 29s., being the same as in Example 1., page 3[illegible]6; this value being selected in order to show more readily the similarity of the present calculation with that in page 396.

1836. Sept	Right ascension.	1st difference.	2d difference	Arc. H. Var. R. A.	1st difference	2d difference
	h. m. s.	m. s.	s.	s.	s	s.
15 *l. c.*	15 36 34.71	29 47.00		146.92	5.40	
16 *u. c.*	16 06 21.71	A=30 50.74	+63.74	151.62	A=5.15	−0.25
16 *l. c.*	16 37 12.45	31 49.20	+58.46	156.77	4.52	−0.63
17 *u. c.*	17 09 01.65			161.29		
			B=+61.10			B=−0.44

		Constant Log.	5.36452
T=3h. 48m. 29s.	=13709s.	Log.	4.13701
A= 30 50 .74	=1850 .74	Log.	3.26735
+ 9 47 .33	=587 .33	Log.	2.76888
+16 06 21 .71	second right ascension.		
− 6 .62	Table XLV. B=61s.10.		
16h. 16m. 02s.42	R. A. in long. of 3h. 48m. 29s. W.		

		5.36452
		4 13701
A= 5s 15	Log.	0.71181
+ 1 .63	Log.	0.21334
+151 .62	second value of H.	
+ .05	Table XLV. B=−0s.44.	
H=153s.30	corresponding to long. 3h 48m 29s. W	

Hence it appears, that, on September 16, 1836, astronomical account, in a place 8h. 48m. 29s west from Greenwich, the right ascension of the moon's bright limb at the time of passing the meridian, was 16h. 16m. 02s.42, and that the arc H, corresponding to that meridian, was 153s 30. This arc H represents the variation of the moon's right ascension between the times of the transit of her bright limb over the two meridians whose longitudes are T — 30m. and T + 30m., corresponding respectively to 3h. 18m. 29s. west, and 4h. 18m. 29s. west, from Greenwich.

In the preceding example, the longitude of the place is given, to find the moon's right ascension at the time of the passage of her bright limb over the meridian of that place; but we may suppose that right ascension to be given, to find, by an inverse process, the longitude of the place of observation, or the time T. The solution of this problem is very similar to that of Problem XIV., page 426, changing *longitude* into *right ascension*, *&c.*; and it may be expressed as in the following rule:—

RULE.

To find the longitude of any place from the moon's right ascension at her transit over the meridian of that place.

1. Take from column 4 of the table of moon-culminating stars, in the Nautical Almanac, the four right ascensions of the bright limb of the moon, as in the above example; and then compute, as in that example, the values of the arcs A, B, in seconds of time.

2. To the constant logarithm 4.63548 add the arithmetical complement of the logarithm of the arc A in seconds of time, and the logarithm of the difference in seconds of time between the given right ascension and the seconds right ascension taken from the Nautical

adding or subtracting the sideral time of the moon's disk passing the meridian, deduced from column 7. Thus, at the upper culmination of the moon, September 16, the right ascension of limb I. is 16h. 06m. 21s.71, in column 4; and in column 7, the sideral time of the moon's semi-diameter passing the meridian is 72s.52, the double of this, or 145s.04=2m. 25s.04, represents the time required for the whole disk to pass the meridian. Adding this to 16h. 06m. 21s.71, we get 16h. 08m. 46s.75, for the right ascension of the limb II., at the time of its transit. In like manner, if the quantity 2m. 25s.04 be subtracted from 16h. 08m. 46s.75, which corresponds to the limb II., we shall get the right ascension corresponding to the limb I., supposing the time of the transit of limb II. to be marked in the Nautical Almanac.

Digitized by Google

Almanac, the sum, rejecting 10 in the index, will be the logarithm of the approximate time T in seconds.

3. Enter Table XLV., with the arc B at the top, and the time T at the side, and find the corresponding correction; to the logarithm of which add the two first logarithms above found; the sum, rejecting 10 in the index, will be the correction of the approximate time, to be applied with the *same* sign as the arc B, and the correct value of T will be obtained, which will express the longitude of the place of observation, if it be west from Greenwich; but if the longitude be east, we must subtract this value of T from 12h. to obtain the true longitude in time east from Greenwich.

EXAMPLE II.

Suppose that, in a place in west longitude, on the 16th of September, 1836, the moon's bright limb passed the meridian in 3m. 20s.65, sideral time, before the star Antares. Required the longitude of the place of observation.

In the Nautical Almanac, column 4, the star Antares or α Scorpii's right ascension, Sept. 16, 1836, was	16h. 19m. 23s.07
Subtract the observed difference of the transits in sideral time	3 20 .65
The remainder is the right ascension of the moon's bright limb at the transit	16 16 02 .42
The next less right ascension in column 4 of the N. A., corresponds to Sept. 16, u. c.	16 06 21 .71
Difference of these right ascensions is 580s.71 =	9m. 40s.71

The four right ascensions to be taken from the Nautical Almanac, are those corresponding to September 15, *l. c.*, September 16, *u. c.*, September 16, *l. c.*, and September 17, *u. c.*, being the same as those in the preceding example, where we have found A = 30m. 50s.74 = 1850s.74, B = + 61s.10. The rest of the calculation is as follows:—

	Constant Log.	4.63548		4.63548
A = 1850s.74	Arith. Comp. Log.	6.73265		6.73265
Diff. of right ascension 580s.71	Log.	2.76396	Equation Table XLV. 6s.58 ....Log.	0.81823
Approx. T = 3h. 45m. 54s.7 = 13554s.7	Log.	4.13209	Correction 2m. 33s.6 = 153s.6 ....Log.	2.18636
Correction = 2 33 .6				

T = 3h. 48m. 28s.3 = the longitude of the place of observation.

This longitude agrees, within a fraction of a second, with the value of the longitude assumed in Example I.; observing that the computed right ascension in Example I. is 16h. 16m. 02s.42, being the same as that which is supposed to be observed in the present example.

When the difference of meridians is small, we may compute their difference from the observed difference of the times of the moon's transit, by means of the arc H, deduced from column 6 of the table of moon-culminating stars, by the following rule:—

RULE.

To compute the difference of meridians by means of the arc H.

1. To the constant logarithm 3.55630 add the arithmetical complement of the logarithm of the arc H, and the logarithm of the difference of the times of the moon's transit over the two meridians in sideral time; the sum, rejecting 10 in the index, will be the logarithm of the difference of meridians expressed in seconds of time

EXAMPLE III.

Suppose that, in a place west from Greenwich, Sept. 16, 1836, the moon's bright limb passed the meridian in 20m. 02s.30, sideral time, after the star Antares. Required the longitude.

It appears by column 4 of the table of moon-culminating stars, that, on September 16, the right ascension of Antares was, 16h. 19m. 23s.07. Adding this to 20m. 02s.30, we get 16h 39m. 25s.37 for the right ascension of the moon's bright limb at the time of its transit over the meridian of the place of observation. Subtracting from this the time of transit at Greenwich, 16h. 37m. 12s.45, taken from column 4 of the table of moon-culminating stars, we get 2m. 12s.92 = 132s.92, for the difference of the times of the transits, to be used in the above rule. Moreover, the arc H, corresponding to the time of the transit at Greenwich, is, by column 6 of the table, H = 156s.77. Then we have,

	Constant Log.	3.55630
Arc H = 156s.77	Arith. Comp. Log.	7.80473
Difference of times of transit 132s.92	Log.	2.12359
Difference of longitude 50m. 52s.3 = 3052s.3	Log.	3.48462

In strictness, the value of H, here used, ought to be increased a little; for, by column 6 of the preceding table, its value for Greenwich is 151s.62, and for a place in the longitude of 12h. west, is 156s.77. The difference between these two values of H, is 5s.15, which represents its increment corresponding to a change of 12h. in the longitude, being at the rate of 0s.429 for a change of 1h. in the longitude; and at this rate the increment for the longitude 50m 52s.3 will be 0s.364, which will be increased to 0s.38, if we notice the correction of

Digitized by Google

second differences depending on the arc B, and compute the arc H as in Example I. Hence the value of the arc H, corresponding to the meridian of the place of observation, is 156s.77 + 0s.38 = 157s.15. If we take the mean of the values of H at Greenwich, 156s.77, and at the place of observation, 157s.15, it becomes H = 156s.96, and with this we may repeat the above calculation, and obtain a corrected result.

	Constant Log. 3.55630
Corrected arc H = 156s.96	Arith. Comp. Log. 7.80421
Difference of times of transit 132s.92	Log. 2.12359
Correct difference of longitude 50m. 48s.6 = 3048s.6	Log. 3.48410

In general, the longitudes of places where such observations are made, are known within a few seconds, so that it will be easy to find at once the value of the arc H, corresponding to the estimated meridian which falls midway between the meridians of the two places of observation; the meridian of Greenwich being used as one of these places, when the times of transit given by the Nautical Almanac are used as if they were actual observations. We shall give the following example of this method :—

EXAMPLE IV.

In a place whose longitude was known to be 3h. 38m. 29s. W. from Greenwich, it was found by observation, on September 16, 1836, that the moon's bright limb passed the meridian 3m. 46s.2, sideral time, before the transit of the star Aldebaran; and in another place, estimated to be 20m. in longitude west from the first place, or in 3h. 58m. 29s. W., the observed difference of the transits was 2m. 55s.0. Required the difference of longitude which results from this observation.

The mean of these two longitudes is 3h. 48m. 29s., and we have found in Example I., that the arc H, corresponding to this meridian on that day, was 153s.30. Moreover, the difference of the two times of transit, 3m. 46s.2, and 2m. 55s.0, is 51s.2; then we have, as in the last example,

		Constant Log. 3.55630
Arc H = 153s.30		Arith. Comp. Log. 7.81446
Difference of times of transit 51s.2		Log. 1.70927
Difference of longitude	20m. 02s.3 = 1202s.3	Log. 3.08003
Add longitude of the first place	3h. 38 29 .0	

Gives the longitude of the second place 3h. 58m. 31s.3 W., as it is deduced from this observation.

PROBLEM XVII.

Given the longitudes of the sun and moon, and the moon's latitude, to find their distance.

RULE.

Find the difference of the two longitudes, and to its log. cosine add the log. cosine of the moon's latitude; the sum, rejecting 10 in the index, will be the log. cosine of the sought distance, which will be of the same affection * as the difference of longitude.

EXAMPLE.

July 20th, 1836, at noon, mean time at Greenwich, by the Nautical Almanac, the sun's longitude was 117° 42′ 31″, the moon's longitude 193° 46′ 05″, and the latitude 2° 47′ 16″ N. Required their distance.

☉'s longitude	117° 42′ 31″	
☽'s longitude	193 46 05	
Difference of longitudes	76 03 34	Cosine 9.38186
☽'s latitude	2 47 16	Cosine 9.99949
Distance	76 04 35	Cosine 9.38135, as in the Nautical Almanac

This is calculated by another method in Example III. of Problem XVIII. In this rule, the sun's latitude is neglected, being only a fraction of a second.

The distances being calculated from noon and midnight by this (or by the following) problem, they may be interpolated for every three hours, by Problem I. The following example will serve for an illustration :—

EXAMPLE.

Given the distances of the sun and moon, in July, 1836, 19d. 12h., 20d. 0h., 20d. 12h. and 21d. 0h., respectively 70° 02′ 35″, 76° 04′ 35″, 82° 11′ 29″, and 88° 23′ 32″. Required the distances, July 20d. at 3h., 6h., and 9h.

---

* Two arcs are said to be of the *same affection* when they are *both greater* than 90°, or *both less than* 90°, but *of different affection* when the one is *greater* and the other *less* than 90°.

Digitized by Google

	d.	h.	Distances ☉ ☾ ° ′ ″	1st difference. ° ′ ″	2d difference ′ ″
1836, July	19	12	70 02 35		
	20	0	76 04 35	6 02 00	+4 54
	20	12	82 11 29	A = 6 06 54	+5 09
	21	0	88 23 32	6 12 03	B = +5 01

	At 3h. ° ′ ″	At 6h. ° ′ ″	At 9h ′ ″
Second longitude	+76 04 35	+76 04 35	+76 04 35
Proportional part.	¼ A = 1 31 43.5	½ A = 3 03 27	¾ A = 4 35 10.5
Table XLV......	T = 3h. corr. −28.2	T = 6h. corr. −38	T = 9h. corr. −28.2
Distances........	At 3h. = 77 35 50	At 6h. = 79 07 24	At 9h. = 80 39 17

These distances agree with the Nautical Almanac.

PROBLEM XVIII.

Given the longitudes and latitudes of the moon and a star, to find their distance.

RULE.

To the log. secant of the difference of longitude of the moon and star, add the log. tangent of the greatest latitude; the sum, rejecting 10 in the index, will be the log. tangent of an arc A, of the same affection as the difference of longitude. Take the *sum* of the arc A, and the least latitude, if the latitudes are of a *different* name, but their *difference* if of the *same* name, and call this sum or difference the arc B. Then add together the log. secant of the difference of longitude, the log. secant of the greatest latitude, the log. cosine of the arc A, and the log. secant of the arc B; the sum, rejecting 30 in the index, will be the log. secant of the distance of the moon and star, which will be of the same affection as B.

EXAMPLE I.

Required the distance of the moon from the star α Pegasi, at noon, mean time at Greenwich, July 9d. 1836, when, by the Nautical Almanac, the moon's longitude, counted from the mean equinox, was 59° 40′ 32″, and her latitude 0° 59′ 15″ N.; the longitude of the star, computed † as in Problem XIX., being 351° 12′ 29″, and its latitude 19° 24′ 29″ N.

☽'s longitude..........	59° 40′ 32″		
✱'s longitude..........	351 12 29		
Difference of longitudes	68 28 03	.........Secant.. 10.43530	.... 10.43530
Greatest latitude......	19 24 29 N.	.......Tangent 9.54693	..........Secant 10.02541
Arc A	43 49 41	........Tangent 9.98223	..........Cosine 9.85819
Least latitude.........	0 59 15 N.		
Difference ‡ is arc B....	42 50 26	....	..........Secant 10.13475
		Distance ✱ ☽ 69° 24′ 00″	.........Secant 10.45365

This distance agrees with the calculated value given in page 146 of the Nautical Almanac.

We may observe, that the log. secant of the distance is also equal to the sum of the log. cosecant of the greatest latitude, the log. sine of the arc A, and the log. secant of the arc B, rejecting 20 in the sum of the indices; but the above rule is in general most convenient, on account of the smallness of the greatest latitude, except when the difference of longitude is nearly equal to 90°.

We may use the same method for finding the distance of the moon from the sun, star, or a planet, when their right ascensions and declinations are given, instead of their longitudes and latitudes. The rule is the same as that we have given above, changing *longitude* into *right ascension*, and *latitude* into *declination*. To exemplify this, we shall compute the same example by this second method.

EXAMPLE II.

Required the distance of the moon from the star α Pegasi, at noon, mean time at Greenwich, July 9d. 1836, when, by the Nautical Almanac, the moon's right ascension was 57° 15′ 01″ from the mean equinox, the moon's declination 21° 3′ 55″ N.; the star's right ascension from the same equinox 344° 9′ 20″, and the star's declination 14° 19′ 32″ N.

☽'s right ascension....	57° 15′ 01″		
✱'s right ascension....	344 09 20		
Difference............	73 05 41	..........Secant.. 10.53642	.... 10.53642
Greatest declination ..	21 03 55 N.	........Tangent 9.58566	..........Secant 10.03004
Arc A.................	52 56 56	.........Tangent 10.12208	..........Cosine 9.77998
Least declination.....	14 19 32 N.		
Difference § is arc B...	38 37 24	....	..........Secant 10.10730
		Distance ✱ ☾ 69° 23′ 58″	.........Secant 10.45364

† We have preferred these computed values, as being rather more accurate than the numbers in Table XXXVII.

‡ The *sum* must be used if the latitudes are of *different* names.

§ The *sum* must be used if the declinations are of *different* names.

Digitized by Google

This differs 2″ from the former method, from the neglect of the tenths of a second in the angles, and from not taking the logarithms to 6 or 7 places of figures.

EXAMPLE III

July 20, 1836, at noon, mean time at Greenwich, by the Nautical Almanac, the sun's right ascension was 119° 47′ 35″, the sun's declination 20° 38′ 23″ N., the moon's right ascension 193° 45′ 07″, and the moon's declination 2° 52′ 03″ S. Required their distance.

☽'s right ascension....	193° 45′ 07″				
☉'s right ascension...	119 47 35				
Diff. of right ascension	73 57 32	..........Secant..	10.55858	....	10.55858
Greatest declination ..	20 38 23 N.	......Tangent	9.57596	..........Secant	10.02881
Arc A................	53 44 11	..........Tangent	10 13454	..........Cosine	9.77196
Least declination.....	2 52 03 S.				
Sum † is arc..........	56 36 14	....		Secant	10.25930
		Distance ☉ ☾	76° 04′ 35″	..........Secant	10.61865

This agrees with the distance marked in the Nautical Almanac.

PROBLEM XIX.

Given the right ascension and declination of a celestial object, with the mean obliquity of the ecliptic E, to find its longitude and latitude.

RULE.

To the log. tangent of the declination add the log. cosecant of the right ascension of the object; the sum, rejecting 10 in the index, will be the log. tangent of the arc A, to be taken out less than 90°, and called *north* or *south*, as the declination is. If the right ascension is *less* than 180°, call the obliquity of the ecliptic *south;* if *above* 180°, *north*. If A and E are of the same name, take their sum, otherwise their difference, which call B, and mark it with the same name as the greater number, whether N. or S. Then add together the log. secant of A, the log. cosine of B, and the log. tangent of the right ascension; the sum, rejecting 20 in the index, will be the log. tangent of the longitude in the same quadrant as the right ascension, unless B be greater than 90°, in which case the quantity found in the same quadrant as the right ascension, subtracted from 360°, will be the longitude.

To the log. sine of the longitude add the log. tangent of B; the sum, rejecting 10 in the index, will be the log. tangent of the latitude, of the same name as B.

Remark. As the Tables of this collection are not marked above 180°, you must subtract 180° from the right ascension, when it exceeds that quantity, and find the log. tangent and log. cosecant of the *remainder;* and then the arc, corresponding to the log. tangent of the longitude, is to be taken of the same affection as this remainder, and 180° added thereto; the sum will be the longitude, unless B is greater than 90°, in which case the supplement of that sum to 360° is to be taken, as observed above.

EXAMPLE.

From the Nautical Almanac we find, that, on the 9th of July, 1836, the right ascension of α Pegasi was 22h. 56m. 37s.35 = 344° 9′ 20″, its declination 14° 19′ 32″ N., and the mean obliquity of the ecliptic 23° 27′ 38″. Required its longitude and latitude.

Declination..	14° 19′ 32″ N.	........Tang..	9.40717			
Right ascens.	344 09 20	..........Cosec.	10.56380	........Tang.	9.45303	
A...........	43 05 12 N.	........Tang..	9.97097	........Secant	10.13648	
E...........	23 27 38 N. [This is S. when R. A. is less than 180°.]					
B...........	66 32 50 N.	....		Cosine	9.59988	........Tang. 10.36268
	✱'s longitude 351° 12′ 29″	..........Tang.			9.18939	........Sine.. 9.18425
	✱'s latitude 19° 24′ 29″ N.	....				Tang. 9.54693

This longitude is counted from the mean equinox, July 9d. 1836, and if we wish to reduce it to the apparent equinox, we must apply to the preceding longitude the equation of the equinoxes deduced from Table XL., which is nearly — 12″; so that the longitude, counted from the apparent equinox, is 351° 12′ 17″, and the apparent latitude 19° 24′ 29″ N. We have, in this example, taken the right ascension and declination of the star from the Nautical Almanac, where they are given to fractions of a second; which is more accurate than Table VIII., where the declinations are given to the nearest minute. We may, however, use the numbers in Table VIII., when great accuracy is not required, correcting for the aberration, as in the precepts to Table XLI. The numbers computed in this problem agree nearly with the results obtained from Table XXXVII.

† The *difference* is to be used if the *declinations* are of the same name.

Digitized by Google

PROBLEM XX.

The longitude and latitude of a celestial object being given, with the mean obliquity of the ecliptic E, to find the right ascension and declination.

RULE.

To the log. tangent of the latitude add the log. cosecant of the longitude; the sum, rejecting 10 in the index, will be the log. tangent of the arc A, which is to be called *north* or *south*, as the latitude is. If the longitude is less than 180°, call the obliquity E *north*; if above 180°, *south*. If A and E are of the same name, take their *sum*, otherwise their *difference*, which call B, marking it with the same name as the greater number. Then add together the log. secant of A, the log. cosine of B, and the log. tangent of the longitude; the sum, rejecting 20 in the index, will be the log. tangent of the right ascension in the same quadrant as the longitude, unless B be greater than 90°, in which case the quantity found in the same quadrant as the longitude, subtracted from 360°, will be the right ascension.

To the log. sine of the right ascension add the log. tangent of B; the sum, rejecting 10 in the index, will be the log. tangent of the declination, of the same name as B.

Remark. If the longitude exceeds 180°, you must subtract 180° from it, and find the log. tangent and log. cosecant of the *remainder*. The arc corresponding to the log. tangent of the right ascension is to be taken of the same affection as this remainder, and 180° added thereto, will be the right ascension, unless B is greater than 90°, in which case the supplement of that sum to 360° is to be taken, as was observed before.

EXAMPLE.

On the 9th of July, 1836, the apparent longitude of the star α Pegasi was 351° 12′ 29″, counted from the mean equinox, the star's apparent latitude 19° 24′ 29″ N., and the mean obliquity of the ecliptic 23° 27′ 38″. Required its right ascension and declination.

Latitude....	19° 24′ 29″	...........Tang.	9.54693			
Longitude..	351 12 29	...........Cosec.	10.81575	........Tang.	9.18939	
A...........	66 32 50 N.	.........Tang.	10.36268	........Secant	10.40012	
E...........	23 27 38 S.	[This is N. when the longitude is less than 180°.]				
B...........	43 05 12 N.	....		Cosine	9.86352	..........Tang. 9.97097
	*'s right ascension 344° 09′ 20″	.....Tang.			9.45303	..........Sine 9.43620
	*'s declination.... 14° 19′ 32″ N.	....				.....Tang. 9.40717

The assumed longitudes in this example are the same as those computed in Problem XIX. by means of the right ascension and declination taken from the Nautical Almanac; being rather more accurate than the results of Table XXXVII. The right ascension and declination computed in this example, agree with those assumed in Problem XIX., which serves as a proof of the correctness of the calculation.

If the given longitude, latitude, and obliquity, are the *mean* values, the resulting right ascension and declination will be the *mean* values; but if the proposed quantities are corrected for aberration and nutation, the resulting quantities will also be corrected. This remark is equally applicable to the preceding problem.

SPHERIC TRIGONOMETRY.

Most of the rules given in the preceding problems may be easily demonstrated by Spheric Trigonometry. As, for example, that of Problem XVII. may be investigated as follows:—In Plate XIV., fig. 1, let A be the place of the moon, C that of the sun, CP an arc of the ecliptic, and AP a circle of latitude passing through the moon, and cutting the ecliptic at right angles, at P. Then the difference of longitude of the sun and moon is equal to the arc CP, and the moon's latitude is AP; whence the distance AC may be found by the rule of Napier, radius $\times$ cos. AC $=$ cos. AP $\times$ cos. CP. This in logarithms gives log. cos. AC $=$ log. cos. AP $+$ log. cos. CP $-$ log. radius, which is the formula made use of. Want of room prevents the insertion of the demonstrations of the methods of calculating the other problems.

The celebrated rules given by Lord Napier, for solving the problems of right-angled spheric trigonometry, being very easily remembered, are much made use of by mathematicians. In a paper communicated by the author of this work to the American Academy of Arts and Sciences, and published in the third volume of the first series of the Memoirs of that society, a method was given for the more easy application of those rules to oblique spheric trigonometry, and as the tables of this collection may sometimes be made use of in solving various problems of spherics besides those given in the former part of this work, it was thought proper to insert this improved method, with the formulas most frequently made use of, to enable any person acquainted with spheric trigonometry, to make use of the tables, without the trouble of referring to another work for the rules.

In every right-angled spheric triangle there are *five circular parts;* namely, the two legs

Digitized by Google

the complement of the hypotenuse, and the complements of the two oblique angles, which are named *adjacent* or *opposite*, according to their positions with respect to each other. The right angle is not included as one of the circular parts, neither is it supposed to separate the legs. In all cases of right-angled spheric trigonometry, two of these parts are given to find the third. If the three parts join, that which is in the middle is called the middle part: if the three parts do not join, two of them must, and the other part, which is separate, is called the middle part, and the other two, opposite parts, as in Plate XIV. fig. 1, 2. Then putting the radius equal to unity, the equations given by Napier will become

Sine of middle part = Rectangle of the tangents of the adjacent parts.
= Rectangle of the cosines of the opposite parts.

The method of applying these solutions to the various cases of right-angled spheric trigonometry, is very simple, and is explained in several treatises. To apply the method to oblique-angled spheric trigonometry, it is necessary to divide the triangle into two right-angled spheric triangles, by means of a perpendicular AP (Plate XIV. fig. 3, 4, 5, 14.) let fall from the point A upon the opposite side BC; the perpendicular being so chosen *as to make two of the given things fall in one of the right-angled triangles*; or, in other words, *the perpendicular ought to be let fall from the end of a given side and opposite to a given angle*.* Each triangle thus found contains, as above, five circular parts, the perpendicular being counted and bearing the same name in each of them; consequently the parts of each triangle similarly situated with respect to the perpendicular, must have the same name. In every case of oblique-angled spheric trigonometry, there are three parts given to find a fourth; and in making use of the method of a solution by means of the perpendicular, there will, in general, be two of these parts in each of the triangles ACP, ABP, similarly situated with respect to each other. To each of these must be joined the perpendicular AP, and there will be three parts in each triangle, which are to be named *middle*, *adjacent*, or *opposite*, according to the above directions. Then the equations for solving all the cases of right-angled, and all except two cases of oblique-angled spheric trigonometry, are,

(1.) *Sine middle part* $\left\{ \begin{matrix} = \\ \propto \end{matrix} \right\}$ *Tangents of the adjacent parts.*† *Cosines of the opposite parts.*

These equations, when applied to right-angled spheric triangles, signify, as before, that the sine of the middle part is equal to the rectangle of the tangents of the adjacent parts, or to the rectangle of the cosines of the opposite parts; but when applied to an oblique-angled triangle, they signify that the sines of the middle parts are proportional to the tangents of the adjacent parts; or that the sines of the middle parts are proportional to the cosines of the opposite parts of the same triangle; observing that the perpendicular, being common to both triangles APB, APC, and bearing the same name in each of them, must not be made use of in the analogies, nor counted as a middle part. This can produce no embarrassment, because the cases of oblique spheric trigonometry may, in general, be solved in the shortest manner, without calculating the perpendicular.

The first case not included in the above rules, is where the question is between two sides and the opposite angles, which may be solved by the noted theorem, that the sines of the sides are proportional to the sines of the opposite angles, or, as it may be expressed in an abridged form for more easy reference,—

(2.) *Sine side* $\propto$ *sine opp. angle.*

This, combined with the above improved formula, furnishes a complete solution of the various cases of spheric trigonometry, except where three sides are given to find an angle, or (which is nearly the same thing, by taking the supplementary triangle) three angles to find a side. The above rules (marked 1, 2,) are simple in their form, and the first varies but little from that made use of by Napier, so that it is extremely easy to remember them. The case not included in these rules may be solved by one of the formulas of Case V. or VI., which may be committed to memory with little trouble. To illustrate these rules, the following examples are given, which include all the cases of oblique spheric trigonometry.

CASE I. Plate XIV., fig. 3, 4, 5, 14.

Given AC, AB, and the opposite angle C, to find BC, and the angles A, B.

In the right-angled spheric triangle APC, are given AC and C, and by marking it as in fig. 2, CP may be found by the rule *sine mid.* = *tang. adj.*, which gives sine (co. C) = tang. CP × tang. (co. AC) or tang. CP = cos. C × tang. AC.‡ Then, in the triangles ABP, ACP, are given AB, AC, and CP, to find BP. If to these is joined the perpendicular AP, it will be found that, in the triangle ACP, the complement of AC is the middle part (as in fig. 3,) and CP an opposite part. The triangle ABP is to be marked in a similar manner. Then the rule *sine mid.* $\propto$ *cos. opp.* gives sine (co. AC) : cos. CP : : sine (co. AB).

* When this can be done in two different ways, (as in Cases II. IV.,) it will generally produce the shortest solution to make use of that perpendicular which does not divide the *required* angle or side into segments.

† It will be of considerable assistance in remembering these rules, to note that the second letters of the words *tangent* and *cosine* are the same as the first letters of *adjacent* and *opposite*. The symbol $\propto$, which is used in this example, signifies *proportional*; thus, $3z \propto z$ signifies that $3z$ is proportional to z, z being any number whatever

‡ In putting this, or any similar expression, in logarithms, the radius must be neglected in the sum of the two logarithms of the second member.

Digitized by Google

cos. BP, and BC = BP $\overset{+}{\sim}$ CP. By marking the segments as in fig. 4, the rule *sine mid.* ∝ *tang. adj.* gives sine CP · tang. (co. C) : : sine BP : tang. (co. B). Having found BC, the angle A may be found by the rule *sine side* ∝ *sine opp. angle*, which gives sine AB : sine C : : sine BC : sine A.

Otherwise—If the side BC is not required, the angles A, B, may be found in the following manner. The rule *sine mid.* = *tang. adj.* gives, by marking as in fig. 1, sine (co. AC) = tang. (co. C) × tang. (co. CAP) or cot. CAP = cos. AC × tang. C; and, by marking as in fig. 5, the rule (sine mid. ∝ tang. adj. or) *tang. adj.* ∝ *sine mid.* gives tang. (co. AC) : sine (co. CAP) : : tang. (co. AB) : sine (co. BAP); then A = BAP $\overset{+}{\sim}$ CAP. By marking the segments as in fig. 14, the rule (sine mid. ∝ cos. opp. or) *cos. opp.* ∝ *sine mid.* gives cos. (co. CAP) : sine (co. C) : : cos. (co. BAP) : sine (co. B) or sine CAP : cos. C : : sine BAP : cos. B. Having A, C, and AB, BC may be found by the rule *sine side* ∝ *sine opp. angle*, which gives sine C : sine AB : : sine A : sine BC.

CASE II. Plate XIV., fig. 3, 4.

Given AC, BC, and the included angle C, to find AB, and the angles A, B.

The rule *sine mid.* = *tang. adj.* gives, as in Case I., tang. CP = cos. C × tang. AC; then BP = BC $\overset{+}{\sim}$ CP, and the rule *cos. opp.* ∝ *sine mid.* gives, by marking as in fig. 3, cos. CP : sine (co. AC) : : cos. BP : sine (co AB,) and, by marking as in fig. 4, the rule *sine mid.* ∝ *tang. adj.* gives sine CP : tang. (co. C) : : sine BP : tang. (co. B). Having found AB, we may find A, by the rule *sine side* ∝ *sine opp. angle*, which gives sine AB : sine C : : sine BC : sine A.

If the angle A had been required, and not B, it would have been shorter to let the perpendicular fall from the point B, by which means the required angle A would not be divided into segments. In this case, the side AB and the angle A might be found in a similar manner to that by which AB and B are found above.

CASE III. Plate XIV., fig. 3, 4, 5, 14.

Given the angles C, B, and the opposite side AC, to find BC, AB, and the angle A.

The rule *sine mid.* = *tang. adj.* gives, as in Case I., tang. CP = cos. C × tang. AC. Then the rule *tang. adj.* ∝ *sine mid.* gives, by marking as in fig. 4, tang. (co. C) : sine CP : : tang. (co. B) : sine BP; then BC = CP $\overset{+}{\sim}$ BP. Again, the rule *cos. opp.* ∝ *sine mid.* gives, by marking as in fig. 3, cos. CP : sine (co. AC) : : cos. BP : sine (co. AB). Having found BC, the rule *sine side* ∝ *sine opp. angle* gives sine AC : sine B : : sine BC : sine A

Otherwise—The rule *sine mid.* = *tang. adj.* gives, as in Case I., cot. CAP = cos. AC × tang. C, and the rule *sine mid.* ∝ *cos. opp.* gives, by marking as in fig. 14, sine (co. C) : cos. (co. CAP) : : sine (co. B) : cos. (co. BAP) or cos. C : sine CAP : : cos. B : sine BAP and A = CAP $\overset{+}{\sim}$ BAP. Then the rule *sine mid.* ∝ *tang. adj.* gives, by marking as in fig. 5, sine (co. CAP) : tang. (co. AC) : : sine (co. BAP) : tang. (co AB). Having found A, the rule *sine side* ∝ *sine opp. angle* gives sine B : sine AC : : sine A : sine BC

CASE IV. Plate XIV., fig. 5, 14.

Given the angles A, C, and the included side AC, to find AB, BC, and the angle B.

The rule *sine mid.* = *tang. adj.* gives, as in Case I., cot. CAP = cos. AC × tang. C and BAP = A $\overset{+}{\sim}$ CAP. The rule *sine mid.* ∝ *tang. adj.* gives, by marking as in fig. 5, sine (co. CAP) : tang. (co. AC) : : sine (co. BAP) : tang. co. (AB). The rule *cos. opp.* ∝ *sine mid.* gives, by marking as in fig. 14, cos. (co. CAP) : sine (co. C) : : cos. (co. BAP) sine (co. B) or sine CAP : cos. C : : sine BAP : cos. B. Having found B, the rule *sine side* ∝ *sine opp. angle* gives sine B : sine AC : : sine A : sine BC.

If the side BC had been required, and not AB, it would be shorter to let the perpendicular fall from the point C, by which means the required side BC would not be divided into segments. In this case, the side BC and the angle B might be found in a similar manner to that by which AB and B are found above.

CASE V. Plate XIV., fig. 3

Given AB, AC, and BC, to find either of the angles, as A.

Put $S = \frac{1}{2}(AB + AC + BC)$. Then the angle A may be found by either of the following theorems, in which, for brevity, the words *sine*, *cosine*, &c., are used for *log. sine log. cosine*, &c.

$$(3.)\ \text{Sine}\ \tfrac{1}{2}A = \frac{\text{sine}\ (S - AB) + \text{sine}\ (S - AC) + \text{cosec.}\ AB + \text{cosec.}\ AC - 20}{2}$$

$$(4.)\ \text{Cos.}\ \tfrac{1}{2}A = \frac{\text{sine}\ S + \text{sine}\ (S - BC) + \text{cosec.}\ AB + \text{cosec.}\ AC - 20}{2}$$

Digitized by Google

CASE VI. Plate XIV., fig. 3.

Given the angles A, B, C, to find either of the sides, as BC.

Put $S = \frac{1}{2}(A + B + C)$. Then the side BC may be found by either of the following theorems, adapted to logarithms, as in the last example.

(5.) $\text{Sine } \frac{1}{2} BC = \dfrac{\text{cosine } S + \text{cosine } (S - A) + \text{cosec. } B + \text{cosec. } C - 20}{2}.$

(6.) $\text{Cosine } \frac{1}{2} BC = \dfrac{\text{cosine } (S - B) + \text{cosine } (S - C) + \text{cosec. } B + \text{cosec. } C - 20}{2}.$

The above include all the cases of Oblique Trigonometry. The 2d and 4th Cases may be solved in a different manner by the following theorems, which, on some occasions, may be found very useful. Thus, both the angles in Case II. may be found by the following theorems:—

(7.) $\text{Sine } \frac{1}{2}(AC + BC) : \text{sine } \frac{1}{2}(BC \sim AC) :: \text{cot. } \frac{1}{2} C : \text{tang. } \frac{1}{2}(A - B)$.

(8.) $\text{Cosine } \frac{1}{2}(AC + BC) : \text{cosine } \frac{1}{2}(BC \sim AC) :: \text{cot. } \frac{1}{2} C : \text{tang. } \frac{1}{2}(A + B)$.

$\frac{1}{2}(A - B)$ is less than $90°$, and $\frac{1}{2}(A + B)$ is of the same affection as $\frac{1}{2}(AC + BC)$. The sum and difference of the terms $\frac{1}{2}(A - B)$ and $\frac{1}{2}(A + B)$ will give A and B.

Both the sides in Case IV. may be found thus:

(9.) $\text{Sine } \frac{1}{2}(A + C) : \text{sine } \frac{1}{2}(A \sim C) :: \text{tang. } \frac{1}{2} AC : \text{tang. } \frac{1}{2}(BC \sim AB)$.

(10.) $\text{Cosine } \frac{1}{2}(A + C) : \text{cosine } \frac{1}{2}(A \sim C) :: \text{tang. } \frac{1}{2} AC : \text{tang. } \frac{1}{2}(BC + AB)$.

$\frac{1}{2}(BC \sim AB)$ is less than $90°$, and $\frac{1}{2}(BC + AB)$ is of the same affection as $\frac{1}{2}(A + C)$. Then the sum and difference of $\frac{1}{2}(BC \sim AB)$ and $\frac{1}{2}(BC + AB)$ give AB and BC.

The improved rule for solving the cases of Oblique Spheric Trigonometry by the circular parts, may be easily deduced from those given by Lord Napier. For if we put M for the middle part, A for the adjacent part, and B for the opposite part of the triangle APC, (fig. 3, 4, 5, 14, Plate XIV.,) m, a, b, for the corresponding parts of the triangle APB, and P for the perpendicular AP; then if P is an adjacent part, the rules of Napier will give $\text{tang. } P = \dfrac{\text{sine } M}{\text{tang. } A}$, and $\text{tang. } P = \dfrac{\text{sine } m}{\text{tang. } a}$; hence $\dfrac{\text{sine } M}{\text{tang. } A} = \dfrac{\text{sine } m}{\text{tang. } a}$; consequently, $\text{sine } M : \text{tang. } A :: \text{sine } m : \text{tang. } a$. If P is an opposite part, the same rule will give $\text{cos. } P = \dfrac{\text{sine } M}{\text{cos. } B}$, and $\text{cos. } P = \dfrac{\text{sine } m}{\text{cos. } b}$; hence $\dfrac{\text{sine } M}{\text{cos. } B} = \dfrac{\text{sine } m}{\text{cos. } b}$; consequently, $\text{sine } M : \text{cos. } B :: \text{sine } m : \text{cos. } b$, which are the two rules to be demonstrated.

Digitized by Google

PROBLEM XXI.

To find the longitude of a place by an eclipse of the sun, when the beginning or end is observed; the apparent time being estimated from noon to noon, according to the method of astronomers; the latitude of the place being also known.

RULE.

1. With the longitude by account, find the corresponding Greenwich *mean time* of the observation. For this time, take out from the Nautical Almanac the sun's right ascension, declination, and semi-diameter, the horizontal parallaxes of the sun and moon, and the moon's declination roughly to the minute.

2. Reduce the latitude, and the moon's horizontal parallax, by subtracting the corrections found in Table XXXVIII.; and subtract from the moon's corrected horizontal parallax the sun's horizontal parallax, and the remainder is the relative parallax.

3. To the proportional logarithm of the relative parallax add the log. secant of the reduced latitude, the constant logarithm 1.1761, and the log. cosecant of double the observed time from noon; (this double time being regarded as P. M. in using Table XXVII., unless it exceeds twelve hours, in which case the excess above twelve hours is to be regarded as A. M.;) the sum, rejecting 20 in the index, is (S).

4. To the sum (S) add the log. cosine of the moon's declination, and the constant log 0.3010; the sum, rejecting 10 in the index, is the proportional log. of an arc in time, which, subtracted from the observed time from noon, gives the corrected time from noon.

5. With the corrected time, the reduced latitude, and the sun's declination, calculate by Rule, page 247, the sun's true altitude.

6. To the log. secant of the sun's true altitude add the log. sine of double the corrected time from noon, (this double time being regarded as P. M. or as A. M., in the same way as before,) and the log. cosine of the reduced latitude; the sum, rejecting 20 in the index, is the log. sine of the parallactic angle.

7. To the proportional log. of the relative parallax add the log. secant of the parallactic angle, and the log. secant of the sun's true altitude; the sum, rejecting 20 in the index, is the proportional log. of the correction for declination. This correction is of the same name with the latitude, when the observed time from noon is less than six hours, and of the different name when this time is greater than six hours. Correct the sun's declination by adding to it the correction for declination if of the same name, and subtracting if of the different name.

8. To the sum (S) add the log. cosine of the sun's corrected declination; the sum, rejecting 10 in the index, is the proportional log. of an arc in time, which is the correction for right ascension, and is additive if the time is afternoon, but subtractive if the time is forenoon. Correct the sun's right ascension by adding the correction for right ascension when additive and subtracting it when subtractive.

9. Multiply the nearest number of minutes in the moon's horizontal parallax by the nearest number of minutes in the sun's semi-diameter, and multiply this product by the factor in the annexed table corresponding to the sun's true altitude; the product, divided by 100, is an arc expressed in seconds, which, subtracted from the sun's semi-diameter, gives the sun's corrected semi-diameter.

Sun's true altitude.	Factor.
0°	0.01
10	0.31
20	0.61
30	0.89
40	1.15
50	1.37
60	1.54
70	1.67
80	1.75
90	1.77

10. To the proportional logarithm of the moon's horizontal parallax (*not corrected*) add the constant logarithm 0.5646; the sum is the proportional logarithm of the moon's semi-diameter.

11. When the observation is the beginning or ending of an eclipse, the distance of the centres of the sun and moon is found by adding the sun's corrected semi-diameter to the moon's semi-diameter. But when the observation is that of the beginning or ending of total darkness in a total eclipse, or that of the formation or of the breaking up of the ring in an annular eclipse, the distance of the centres of the sun and moon is found by taking the difference between the sun's corrected semi-diameter and the moon's semi-diameter.

12. Assume, from inspection of the Nautical Almanac, a convenient time when the moon's right ascension differs but little from the sun's corrected right ascension, and for this time take out *new* right ascensions, and *new* declinations of the sun and moon, and their horary motions in right ascension and declination by Problems I. and II.

13. From the hourly motion of the moon in right ascension subtract that of the sun, the remainder is the relative motion in right ascension.

The difference between the hourly motion of the moon in declination and that of the sun is the relative motion in declination.

Correct the sun's *new* right ascension, by adding the correction for right ascension when it is additive, and subtracting when it is subtractive.

Correct the sun's *new* declination, by adding the correction for declination when it is of the same, and subtracting it when it is of the different name.

14. Subtract the logarithm of the difference between the sun's new corrected right ascension and the moon's right ascension from the logarithm of the relative motion in right ascension, and call the remainder R.

15. To the remainder R add the constant log. 0.4771; the sum is the proportional logarithm of an arc in time, to be $\left\{\begin{array}{l}\text{added to}\\\text{subtracted from}\end{array}\right\}$ the assumed time when the sun's *new* corrected right ascension is $\left\{\begin{array}{l}\text{greater}\\\text{less}\end{array}\right\}$ than the moon's right ascension, to get the *new corrected* time.

16. To the remainder R add the proportional logarithm of the relative motion in declina-

Digitized by Google

sion, the sum is the proportional logarithm of a correction of the moon's declination Whether this correction is additive or subtractive is thus determined: — Find three numbers as follows: —

If the moon's declination is $\left\{\begin{matrix}\text{increasing,}\\ \text{decreasing,}\end{matrix}\right\}$ the first number is $\left\{\begin{matrix}1\\ 2\end{matrix}\right\}$.

If the moon's motion in declination is $\left\{\begin{matrix}\text{greater}\\ \text{less}\end{matrix}\right\}$ than the sun's, the second number is $\left\{\begin{matrix}1\\ 2\end{matrix}\right\}$

If the sun's new corrected right ascension is $\left\{\begin{matrix}\text{greater}\\ \text{less}\end{matrix}\right\}$ than the moon's right ascension, the third number is $\left\{\begin{matrix}1\\ 2\end{matrix}\right\}$

If the sum of these numbers is $\left\{\begin{matrix}\text{odd,}\\ \text{even,}\end{matrix}\right\}$ the correction is $\left\{\begin{matrix}\text{additive,}\\ \text{subtractive.}\end{matrix}\right\}$

The result gives the moon's *new* corrected declination.

17. To the logarithm of the relative motion in right ascension add the log. cosine of the moon's new declination, (not corrected,) and call the sum (S_1).

18. To the sum (S_1) add the proportional logarithm of the relative motion in declination, and the constant logarithm 7.1427; the result is the logarithm cotangent of the *first* orbitical inclination, which is

$\left.\begin{matrix}\text{N.}\\ \text{S.}\end{matrix}\right\}$ when the sun's motion in declination is $\left\{\begin{matrix}\text{greater}\\ \text{less}\end{matrix}\right\}$ than the moon's.

19. To the proportional logarithm of the difference between the sun's *new* declination corrected and the moon's, add the logarithm secant of the *first* orbitical inclination, and from the sum deduct the prop. logarithm of the distance between the centres of the sun and moon; the remainder is the log. secant of the second orbitical inclination, which has the name $\left.\begin{matrix}\text{S.}\\ \text{N.}\end{matrix}\right\}$ when the observation is an $\left\{\begin{matrix}\text{immersion,}\\ \text{emersion.}\end{matrix}\right.$

This inclination is greater than 90° when the sun's new corrected declination is greater than the moon's; otherwise less than 90°.

20. *Add* together the two orbitical inclinations if of the *same* name, and *subtract* them if of *different* names; and call the result the relative inclination, which must have the same name as the greater of the two orbitical inclinations.

To the log. cosecant of the relative inclination add the sum (S_1), the proportional log. of the distance of the centres of the sun and moon, and the constant log. 7.6198; the sum, rejecting 20 in the index, is the prop. log. of an arc in time, to be applied to the *new* corrected time to get the *mean* time at Greenwich; it must be

$\left.\begin{matrix}\text{added}\\ \text{subtracted}\end{matrix}\right\}$ when the relative inclination is $\left\{\begin{matrix}\text{N.}\\ \text{S.}\end{matrix}\right.$

21. By applying to the Greenwich mean time the equation of time taken from page II of the Nautical Almanac, we shall have the *apparent time* at Greenwich; the difference between it and the apparent time of observation will show the longitude of the place from Greenwich.

EXAMPLE.

Suppose, at a place in the latitude 42° 31′ 13″ N., and estimated longitude 4h. 43m. 38s.6 the *end* of a solar eclipse was observed, November 30, 1834, at 4h. 5m. 47s.5 *apparent time* *Required the longitude.*

ELEMENTS OF THE ECLIPSE.	END.			
Apparent time of observation.................November	30d.	4h.	5m.	47s.5
Estimated longitude.................W.		4	43	38 .6
Apparent time at Greenwich.................	30	8	49	26 .1
Equation of time.................*subtract*			11	2 .4
Mean time at Greenwich.................	30	8	38	23 .7
☉'s right ascension.................		16	25	53 .05
☉'s declination.................S.		21°	41′	52″.6
☉'s semi-diameter.................			16	14 .8
☉'s horizontal parallax.................				8 .7
☽'s horizontal parallax.................			60	20 .14
☽'s declination.................		21	7	6 .8
Latitude of the place — Corr. Table XXXVII. = *reduced latitude*.....		42	19	47 .4
☽' horizontal parallax — Corr. Table XXXVIII. = 60′ 20″.14 − 5″.54 is ☽'s *corrected horizontal parallax*.................			60	14 .6
☽'s *corrected* horizontal parallax — ☉'s hor. par. = *relative parallax*....			60	5 .9
ELEMENTS FOR NOV. 30d. 8h.				
☽'s *new* right ascension.................		16h.	29m.	13s.35
☽'s *new* declination.................S.		21°	01′	24″.6
☉'s *new* right ascension.................		16h.	25m.	46s.15
☉'s *new* declination.................		21°	41′	39″ 9
☽'s horary motion in right ascension.................			2m.	33s.79
☽'s horary motion in declination.................			8′	59″.3
☉'s horary motion in right ascension.................				10s.79
☉'s horary motion in declination.................				24″.05
☽'s horary motion in right ascension — ☉'s horary motion in right ascension = *relative* motion in right ascension.................			2	23
☽'s horary motion in declination — ☉'s horary motion in declination = *relative* motion in declination.................			8	35 .25
☉'s *new* right ascension + corr. for right ascen. = *corr.* new right as..		16	28	33 .3
☉'s *new* declination — corr. declination = *corr.* new declination......		20°	56′	7″.9

Digitized by Google

Relative parallax 60 5″.9.....Prop. Log. 0.4764
Reduced latitude 42° 19′ 47″.4.........Secant 10.1312
Constant Log. 1.1761
Double obs'd time fr. noon 8h. 11m. 35s. Cosec. 10.0563

Sum......(S)................................ 1.8400
☽'s declination 21° 7′ 6″.8............Cosine 9.9698
Constant Log. 0.3010

Prop. Log. correction..... 1m.23s.7........ 2.1106
Observed time fr. noon 4h 5 47 .5

Corrected time from noon 4h.4m.23s.8 Log.ris. 4.71324
Reduced latitude 42° 19′ 47″.4.........Cosine 9.86881
☉'s declination 21 41 52 .6.........Cosine 9.96809

Nat. number..................35493........ 4.55014
Nat. cosine......64 01 40 43794

Nat. sine ☉'s *true altitude*......08301 = 4° 45′ 41″

☉'s true altitude 4° 45′ 41″...........Secant 10.00150
Double corrected time fr. noon 8h. 8m. 47s.6 } Sine (P.M.) } 9.94223
Reduced latitude 42° 19′ 47″.4.......Cosine 9.86881

Parallactic angle.....sine 40° 30′ 00″..... 9.81254

Rel. parallax 60′ 5″.9..............Prop. Log. 0.4764
Parallactic angle 40° 30′...............Secant 10.1190
☉'s *true* altitude 4° 45′ 41′............Secant 10.0015

Correction ☉'s declination P. L. 45′ 39″ N. 0.5969

☉'s declination................21° 41 52.6 S

☉'s corrected declination...20 56 20.6 S

Sum......(S) 1.8400
☉'s corrected declination 20° 56′ 20″.6..Cosine 9.9703

Correction ☉'s right ascen. P. L. 2m. 47s.15 1.8103

☉'s right ascension.......... 16h. 25m. 53s.05

☉'s corrected right ascen. 16 28 40 .2

$\frac{60 \times 16 \times 0.143}{100}$ = diminution ☉'s semi-diam. 1′.4

☉'s semi-diameter..........................16′ 14″.8

☉'s corrected semi-diameter.............16 13 .4

☽'s horizontal parallax 60′ 20″.14...Prop. Log. 4747
Constant Log. 5646

☽'s semi-diameter.......Prop. Log. 16 26″.5 1.0393

☉'s corrected semi-diameter........16 13 .4

Distance of the centres of ☉ & ☽ 32 39 .9

The time when the moon's right ascension differs but little from the sun's corrected right ascension, is November 30d. 8h., for which Greenwich time we take the following by inspection: —

	h.	m.	s.
☽'s *new* right ascension............	16	29	13.35
☽'s *new* declination south........... ...	21	01	24.6
☉'s right ascension, Nov. 30d............	16	24	19.86
Dec. 1	16	28	38.72
Difference for 24 hours..................	4		18.86
for 8 hours..................	1		26.29
☉'s new right ascension...............	16	25	46.15

☉'s *declination, by Problem I*

Nov 29d	+21° 29′ 22″.8		
30	+21 38 24 .8	+ 0′ 02″.0	
Dec 1	+21 48 2 .0	A 9 37 .2	− 24″.8
2	+21 57 14 .1	+ 9 12 .1	− 25 1
			− 25 B

Second declination....................+ 21° 38′ 24″.8
A 9′ 37″.2 Prop. part...................+ 3 12 .4
B 25 Table XLV.......................+ 2 .7

☉'s new declination................... 21 41 39 .9

☽'s *horary motion in right ascension, by Problem II.*

	h.	m.	s.
Nov. 30d. 7h. ☽'s right ascension......	16	26	59.67
8 " " "	16	29	13.35
9 " " "	16	31	47.25

Horary motion for 7h. 30m.................... 2 33.68
for 8 30 .... 2 33.90

☽'s horary motion at 8h. in r. as.......... 2 33.79

☽'s *horary motion in declination, by Problem II.*

Nov. 30d. 7h. ☽'s declination.........20° 59′ 20′.8
8 " " ....21 1 24 .6
9 " " ....21 10 19 .4

Horary motion for 7h. 30m..... ....9 3 .8
for 8 30 ....8 54 .8

☽'s horary motion at 8h. in declination 8 59 .3

	h.	m.	s.
☉'s right ascension, Nov. 30d............	16	24	19.86
Dec. 1	16	28	38.72

Motion in right ascension in 24 hours.....24) 4 18.86

☉'s horary motion in right ascension 10.79

☉'s declination, Nov. 30................21° 38′ 24″.8
Dec. 1................21 48 2 .0

Motion in declination in 24 hours.......24) 9 37 .2

☉'s horary motion in declination... 24 .05

☉'s *new* corrected right ascension....16h. 28m. 33s.3
☽'s right ascension..................16 29 13 .35

Difference........................... 40 .05

Log. of 40.05..................................1.60260
Relative motion in right ascens. 143″.........2.15534

Remainder ......R........ .... 0.55274
Constant Log. 0.477′

Arc in time.......Prop Log. 16m.48s 4 1.0298
Assumed time..............8h. 0 0

New corrected time ......7 43 11 .6

Remainder ......R......................... 0 5527
Relative motion in declination 8′ 35″.25..P. L 1.3214

Correction ☽'s declination P. L. 2′ 24′.3 1.874′

☽'s declination....... ....21 1 24 .6

☽'s new corrected declin.....20 59 00 .3

Relative motion in right ascen. 143″ 2.1553
☽'s *new declination*........21° 1′ 24 .6....Cos 9.9701

Sum......(S,)................................ 2.1254
Relative motion in declination 8′ 35″.25...P. L. 1.3214
Constant Log. 7.1427

1st orbitical inclination...*Cotan.* 14° 26′ S. 10.5895

☉'s new declin. corrected 20° 56′ 7″.9
☽'s new declin. corrected 20 59 0 .3

2 52 .4...P L. 1.7969

Secant 1st orbitical inclination 14° 26′ 10.0139

11.8108
Distance of the centres ☉ & ☽ 32′ 39″ 9.. P L 7419
2d orbitical inclin. Sec. 85° 7 N. 11.0696
1st orbitical inclination....14 26 S.

Relative inclination ....70 41 N ..Cosec 10.0252

Sum......(S,)................................ 2.1254
Distance of the centres ☉ & ☽....Prop. Log. 0.7419
Constant Log. 7.6192

Correction in time.... 55m. 25s. Prop Log. 0.5116
New corrected time...7h.43 11 .6

Greenwich mean time...8 38 36 .6
Equation of time..... 11 2 .4

Apparent time ....8 49 39 .0 *at Greenwich.*
Apparent time.......4 5 47 .5 *observed.*

Longitude ....4 43 51 .5 required

PROBLEM XXII.

To find the longitude of a place by an occultation of a star by the moon; the apparent time being estimated from noon to noon, according to the method of astronomers, and the latitude of the place being known.

RULE.

With the longitude by account find the corresponding Greenwich *mean* time of observation. For this time, take out from the Nautical Almanac the sun's right ascension, the moon's horizontal parallax, and her declination, to the nearest minute

Reduce the latitude of the place, and the moon's horizontal parallax. by subtracting the corrections found in Table XXXVIII.

To the sun's right ascension add the *apparent* time of observation; the sum will give the right ascension of the meridian.

Take from the tables "for facilitating the computation of occultations of certain stars by the moon," in the Nautical Almanac, the star's right ascension and declination. The difference between the right ascension of the meridian and the star's right ascension will give the hour-angle of the star, which convert into degrees, &c., naming it *west* when the right ascension of the meridian is *greater* than the star's right ascension, and *east* when *less*.

To the proportional logarithm of the moon's corrected horizontal parallax add the log secant of the reduced latitude, and the log. cosecant of the hour-angle, rejecting 10 in each index. To the *sum* (S) add the log. cosine of the moon's declination and the constant logarithm 0.3010; the result, rejecting 10 in the index, will give the proportional logarithm of an arc, which, subtracted from the hour-angle, will give the hour-angle corrected.

Take out the following logarithms, and place them beneath each other, in two columns:— the proportional log. of the moon's corrected horizontal parallax in both columns; the secant of the star's declination in col. 1, and its cosecant in col. 2; the cosecant of the reduced latitude in col. 1, and its secant in col. 2; and the secant of the corrected hour angle in col. 2. The sum of the logarithms in col. 1 will give the prop. log. of an arc of the *same* name as the latitude, and the sum of the logarithms in col. 2 will give the prop log. of an arc of a *different* name from the star's declination, when the hour-angle is *less* then 90°, but of the same name, if *greater* than 90°. The sum of these arcs, having regard to their names, will, being applied to the star's declination, give the declination corrected.

To the sum (S) add the constant log. 1.1761, and the log. cosine of the star's corrected declination; the sum, rejecting 10 in the index, will be the prop. log. of an arc in time to be *added* to the star's right ascension when it is *west* of the meridian, but *subtracted* when *east*, to obtain the star's right ascension corrected.

Find in the Nautical Almanac the time when the moon's right ascension is near to that of the star corrected, and for this time take out the moon's right ascension and declination and their hourly variations.

Subtract the common log. of the difference between the corrected right ascension of the star and the right ascension of the moon from the common log. of the hourly motion in right ascension; to the remainder add the constant log. 0.4771; to the same remainder add the proportional log. of the hourly motion in declination. The *former* sum will be the proportional log. of a time to be *added* to the assumed time when the star's right ascension is *greater* than the moon's, otherwise *subtracted*, to obtain the *time corrected*. The *latter* will be the proportional log. of a correction of the moon's declination, to be applied with the *same* name as the hourly variation when the star's right ascension is *greater* than the moon's right ascension, but with a *different* name when *less*.

To the common log. of the hourly motion in right ascension add the log. cosine of the moon's declination; to the sum (S_1), rejecting 10 in the index, add the proportional log. of the hourly motion in declination, and the constant log. 7.1427. The result will be the log cotangent of the first orbitical inclination, and must have the *same* name as the hourly motion in declination, when the star is *north* of the moon, but a *different* name when *south* of the moon.

To the proportional log. of the difference between the star's declination corrected and the moon's declination corrected add the constant log. 9.4354, and the log. secant of the preceding orbitical inclination, rejecting 10 in the index, and from the sum subtract the proportional log. of the horizontal parallax; the remainder will be the log. secant of the second orbitical inclination, which must be named S. when the observation is an *immersion*, and N. when an *emersion*.

Add together the two orbitical inclinations, having proper regard to their names; and to the log. cosecant of this sum add the preceding sum (S_1), the proportional log. of the horizontal parallax, and the constant log. 8.1844. The sum will be the proportional log. of a correction to be applied to the time corrected to get the *mean time at Greenwich;* added when the sum of the orbitical inclinations is N., subtracted when S.

Apply the equation of time to this Greenwich mean time, and we shall have the Greenwich *apparent time;* the difference between it and the apparent time at the place of observation will give the longitude required *west* when the time at Greenwich is the greatest *east* when *less*

EXAMPLE.

Suppose, in a place in the latitude 42° 19′ 15″ north, and estimated longitude 4h. 44m. west of Greenwich, the *immersion* of γ Cancri was observed April 20, 1839, at 10h. 45m. 35s.9 *apparent time*. Required the longitude.

P. L. ☽'s corrected hor. par.	56′ 9″.4	0.5059
Secant reduced latitude	42° 7 50	0.1298
Cosecant hour angle	61 7 48	0.0576
Sum (S)		0.6933
Cosine ☽'s declination	22° 42′ 06″	9.9650
	Constant Log.	0.3010
Proportional Log. correction	19′.46″	0.9593
Hour-angle	61° 7 48	
Hour-angle corrected	60 48 02	

ELEMENTS OF OCCULTATION.	IMMERSION.
	d. h. m. s.
Apparent time of observation, ... April	20 10 45 35.9
Estimated longitude ... W.	4 44 0
Apparent time at Greenwich	20 15 29 35.9
Equation of time ... subtract	1 11.4
Mean time at Greenwich ... April	20 15 28 24.5
☉'s right ascension	1 52 54.3
☉'s right ascension + appar. time of obs. = right ascension meridian	12 38 30.2
☽'s horizontal parallax	56′ 14″.5
Correction Table XXXVIII	5 .1
☽'s *corrected* horizontal parallax	56 9 .4
☽'s declination ... N.	22° 42 06 .1
✱'s right ascension	8h. 33m. 59s. 03
✱'s hour-angle	4 4 31 .17
✱'s hour-angle, in degrees, &c. ... W.	61° 7 48′
✱'s declination ... N.	22 2 38 .5
Lat. place — corr. Table XXXVIII = *reduced latitude*	42 7 49 .7
By the Nautical Almanac we find the moon's right ascension to be nearest to the star's corrected right ascension on 20th April, at 16 hours, for which time we get the	h. m. s.
☽'s right ascension	8 37 5.03
☽'s horary motion in right ascension	2 11.38
☽'s declination ... N.	22° 36′ 55″.0
☽'s horary motion in declination ... S.	9 53.85

Col. 1.		Col. 2.	
P. L. ☽'s corr. H. P. 56′ 9″.4	0.5059	Same	0.5059
Secant ✱'s decl. 22° 2′ 38″	0.0330	Cosecant	0.4256
Cosec. red. lat. 42 7 50	0.1734	Secant	0.1298
Prop. Log. 34′ 54″.5 N.	0.7123	Sec. cor. h. a. 60° 48′ 2″	0.3117
7 37 .6 S.		Prop. Log.	1.3730
27 16 .9 N.		Sum (S)	0.6933
✱'s declin. 22° 2 38 .5 N.		Const. Log.	1.1761
✱'s corr. dec. 22 29 55 .4 N.		Cosine	9.9656

Correction	0h. 2m. 37s. 93	P. L. 1.8350
✱'s right ascension	8 33 59 .03	
✱'s *right ascen. corr.*	8 36 36 .96	
☽'s right ascen.	8 37 5 .03	
Difference	28 .07	

Log.	28″.07	1.4482		
Log. ☽'s hor. mo. in r. as.	131″.38	2.1185		
Remainder		0.6703	Remainder	0.6703
	Constant Log.	0.4771	P. L. ☽'s ho. mo. in dec. 9′ 53″.85	1.2597
Prop. Log.	12m. 49s.2	1.1474	Prop. Log. 9′ 6″.9 N.	1.9300
Assumed time	16h. 0 0		☽'s declination 22° 36 55 N	
Time corrected	15 47 10 .8		☽'s *declination corr.* 22 39 01 .9 N	

Log. ☽'s hor. mo. in right ascension 131″.38		2.1185
Cosine ☽'s declination 22° 36′ 55″		9.9653
Sum (S₁)		2.0838
P. L. ☽'s hor. mo. in declination 9′ 53″.85		1.2597
	Constant Log.	7.1427
Cotangent 1st orbitical inclination 18° 5 N.		10.4862

✱'s declination corr.	22° 29′ 55″.4	
☽'s declination corr.	22 39 01 .9	
Difference	9 06 .5	Prop. Log. 1.2958
	Constant Log.	9.4354
Secant 1st orbitical inclination	18° 5′	10.0220
		10.7532
P. L. ☽'s horizontal parallax	56′ 14″.5	0.5052
Secant 2d orbitical inclin.	55° 36 S.	10.2480
1st orbitical inclination	18 05 N.	
Difference	37 31 S.	Cosec. 10.215.
Sum (S₁)		2.0838
P. L. ☽'s horizontal parallax	56′ 14″.5	0.5052
	Constant Log	8.1844
Prop. Log. of correction	18m 28s.3	0.9868
Corrected time	15h. 47 10 .8	
Mean Greenwich time	15 28 42 .5	
Equation of time	1 11 .4	
Apparent time at Greenwich	15 29 53 .9	
Apparent time of observ.	10 45 35 .9	
Longitude in time	4 44 18	

Digitized by Google

ON WINDS AND STORMS.

BY W. C. REDFIELD.

THE earth is surrounded by a fine, invisible and elastic fluid, called *air*; which when spoken of in its general relations to the earth, is called the *atmosphere*. Its incumbent weight or pressure upon the earth's surface is determined by means of the barometer and is equal to a column of mercury of about thirty inches in height, at the sea level

Wind, is air in motion. It is found, that in almost every country and in every sea the wind is more or less predominant in a particular direction. The most remarkable of these general winds are distinguished by several names, as *trade winds*, *monsoons*, *variable winds*, *&c.*

The *trade winds*, are found between the equator and the 30th parallels of north and south latitude, where the wind, for the most part, blows from the eastward: but near the eastern borders of any ocean, the trade winds usually blow more towards the equator than in its more central portions; while on the western borders, the wind not unfrequently, blows in a direction which is more or less outward from the equator.

The *monsoons*, which are chiefly found in the Indian seas, are regular alternations of the trade winds, which blow for six or eight months in their regular course; but, during the other portions of the year, are replaced by a westerly wind: which is probably a deflection of the trade wind from the opposite side of the equator.

The *variable winds*, are chiefly found extending from the outward borders of the trade winds to the polar regions; although subject to frequent changes, both of velocity and direction, yet their predominating direction is found to be from a western quarter being opposite to the general course of the trade winds. The various movements of these winds are often exhibited in different strata, superimposed one upon another; and these movements viewed in their extended relations, are doubtless connected with those of the trade winds.

The *land* and *sea breezes*, are daily alternations in the direction of the general winds, near the shores of an island or continent. They appear to be connected with the daily changes of temperature at the earth's surface. The sea breeze generally sets in about ten in the forenoon and continues till about five or six in the evening: at seven the land breeze begins and continues till about eight in the morning.

A *whirlwind*, is a phenomenon which is often violent and dangerous. The identity of *waterspouts* and whirlwinds was maintained by Franklin, and although at a later period this has sometimes been questioned, it appears to have been done without sufficient reason. From the equal distribution of the atmosphere as the envelop of our earth, it results, that no violent wind can take place, except by means of a movement which is more or less circuitous in its character, and in cases of great violence, the wind is exhibited in the form of an active vortex or whirlwind; which, if isolated from other violent winds and of small extent, is often called a *tornado* or *waterspout*.

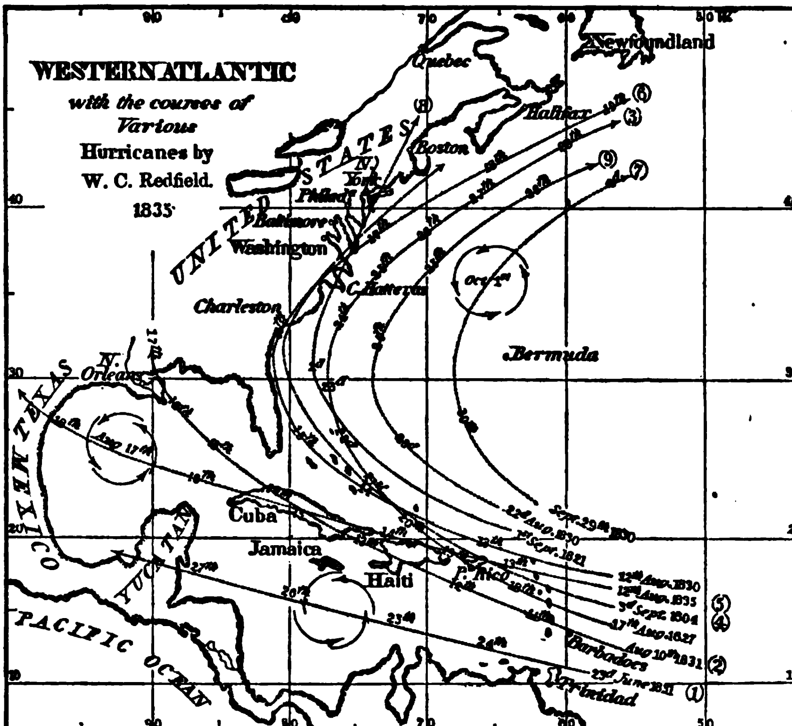
Waterspouts and whirlwinds follow the course either of the surface wind, or of a higher current of air from which they are sometimes depended; or their course may be modified by both these influences, without being absolutely determined by either. They abound most in those calm regions which are found near the external limits of the trade winds and in like regions near the equator.

Storms and *hurricanes*, have from the earliest periods been considered as the chief dangers encountered by the navigator. It was discovered by Franklin, that northeast storms, in the United States, pursued a retrogressive course, commencing sooner in Philadelphia than in Boston. Careful attention having been given to the phenomena of the Atlantic storms, in later years, it has been found that they exhibit certain characteristics of great uniformity. The most violent of these storms, often known by the name of *hurricanes*, appear to commence in the intertropical latitudes, eastward of the West Indies, where their course is towards the northwest, till approaching the latitude of 30°, their westerly progress ceases and their track becomes recurved to the northward and eastward; in which latter direction their progress usually becomes accelerated.

On the annexed chart, the routes of several of these hurricanes are shown by dotted lines, which indicate, somewhat nearly, the center of the track pursued by each hurricane in its daily progress, on such part of its route as has become known.

The rate at which these storms advance in their course, is from eleven to thirty miles an hour; their average progress being about seventeen miles. This cannot explain the velocity of the wind, which, in the most violent part of the gale, sometimes exceeds 80 or 100 miles an hour: but the observations by which their course and velocity have

Digitized by Google



Cerography.

een determined have also shown, that these storms act in the manner of great whirlwinds, turning constantly to the *left* around their moving axis of rotation: the most violent portion of the gale being found toward the interior or heart of the storm. Hence it is also found, that the direction of the wind in a gale, for the most part, does not at all coincide with its line of progress.

When a storm is about to commence, the latitude of the ship will indicate its probable course, as is seen on the above chart, and the direction of wind which the storm first presents, may serve to determine the portion of the gale under which the ship is likely to fall, either by preserving, or altering her course; as well as the changes and comparative violence of the wind, to which she will, in either case, be exposed.

In the hurricane figures which are found on the chart on tracks 1, 5, and 7, the curved arrows show the various directions of the wind in different portions of the advancing storm: but in order to exhibit this more perfectly, the annexed diagram may be referred to. The outward circle of this diagram represents the true points of the compass, and the curved arrows in the figure within, represent the rotary motion of the gale, and serve to show, somewhat nearly, the direction of the wind in all parts of the storm. The *indicator* C, shows the general course of the storm in the intertropical latitudes, which as the storm moves onward to the higher latitudes, changes gradually round to NE. and ultimately to nearly east. Thus, on the coast of the United States northward of Charleston or Cape Hatteras, the gale, on its *central* section, will begin from E. to SE. and its close, after the passage of its center, will be from the NW. quarter; for the wind always blows *across* the path of the storm *on the center of its track.*

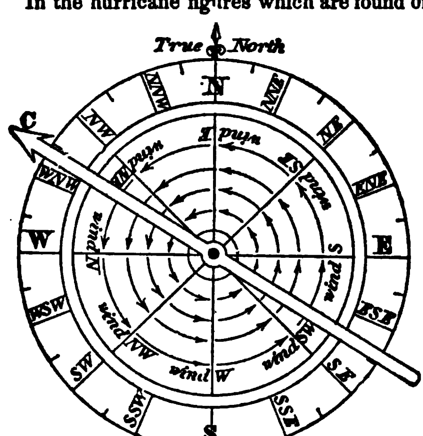


Diagram for north latitude

Toward the outward margin of the storm or remote from the center of its path, the gale becomes less severe and the changes of wind more gradual and less hazardous. The navigator should so lay his ship, therefore, as to avoid the heart of the storm, and at the same time, to take the changes of wind which are to follow in the most favorable manner.

It will be found more difficult to form a just estimate of the direction and changes of the approaching gale in the latitudes near the outward borders of the trade winds and thence to 31° or 32°, than in other latitudes; for here the storm is rapidly changing its course, and the changes of wind cannot therefore be so accurately estimated.

Diagram for south latitude

In *south latitudes* the course of storms is found to be in the *reverse order* to those which are traced on the chart; their progress being *northwesterly* in the intertropical latitudes, while on approaching the latitude of 30° south, they recurve towards the *south* and *southeast*. The rotary motion of the gale is also in the opposite direction from that which is found in the northern hemisphere, being *to the right*, around the moving axis of rotation, as is shown in the annexed diagram for south latitude. The indicator C, here shows the storm as moving southwesterly, and a gradual change, by south, to south east, will show the various directions and changes which pertain to the progress of the storm in different south latitudes.

When the course of a ship at the commencement of a gale, is found to be across the track of the storm, the direction as well as force of the gale may be greatly affected by this gradual change of position. These changes of wind, as well as those to which a stationary vessel would be exposed, by the onward movement of the storm, may be understood by consulting the chart and diagrams: the latter, for the sake of convenience, may be drawn on a card and used upon the common charts.

If a ship is hove too and no attempt made to avoid the heart of the storm, it is apparent that her exposure may greatly depend upon the tack on which she is laid. This was strikingly exemplified in the Culloden's storm of March, 1809, in the Indian ocean, lat. 23° S. The Culloden, with a convoy of Indiamen, took the gale at SE. and the ships which were hove too with their heads to the southward were soon out of the gale, while those ships which stood on to the westward were either lost, or continued for a long time exposed to the full severity of the hurricane.*

It is owing probably, to the centrifugal action of these rotative storms, that the barometer always sinks under the first portion and towards the center of the storm, in all latitudes; and this fall of the barometer commonly affords the earliest and surest indication of the approaching tempest. When the center or axis of the storm has passed, the barometer commences rising, whether the wind has already been violent or not, and in some positions, as off the Cape of Good Hope, the last part of the storm with a rising barometer, usually exhibits the greatest violence of wind. The state of the barometer should always be recorded at regular and frequent intervals, in the log book or journal.

Observations on the duration and strength of the wind and the movements of the barometer on opposite sides of a storm have shown that in most cases the rotary action of the wind is not entirely uniform in its development; although the characteristic movements of rotation are clearly distinguishable. The rotation appears to be manifested most equally in storms which are distinguished for their activity and violence.

Humboldt estimates the extreme velocity of the tropical tornadoes at two or three hundred miles an hour. The velocity of a heavy gale is from 60 to 100 miles.

Colonel Beaufoy states that wind has only the 666th part of the effect of water, when moving with equal velocity. He observes also, that it frequently happens in violent storms of wind the current does not reach any considerable altitude; for often at the height of 1,600 feet, there is a perfect calm; on the contrary, it is not uncommon for the wind at considerable elevations above the level of the sea, to move with very great celerity, whilst the lower parts of the atmosphere remain in a state of tranquility.

* See Reid on the Law of Storms: London, 1838, p. 169-215

Digitized by Google

TABLE LIV.

(CONTINUED.)

Latitudes and Longitudes.

Islands, &c., in the SOUTH AND NORTH PACIFIC OCEANS.

Group	Place	Lat. D.	Lat. M.	Long. D.	Long. M.
Paumotu Group, or Low Archipelago.	Clermont de Tonnere, (S. E. pt.)	18	33 S	136	21 W
	Serle Island, (S. E. pt.)	18	21	137	04
	Henuake, or Honden I.	14	56	138	48
	Disappointment Islands, —Wytoohee (N. W. pt.)	14	10	141	18
	—Otooho, (centre)	14	05	141	30
	Taiara, or King's Island, (centre)	15	42	144	39
	Raraka Island, (entrance to Lagoon)	16	06	144	58
	Kawahe, or Vincennes Island, (S. pt.)	16	0	145	10
	Aratica, or Carlshoff Island, (west end)	15	33	145	39
	Manhii, or Wilson's Island, (west end)	14	26	146	04
	Ahii, or Peacock Island, (west end)	14	34	146	25
	King George's group, — Tiokea, (S. W. pt.)	14	31	145	10
	— Oura, (S. pt.)	14	44	145	20
	Rurick, or Arutua Island, (west end)	15	15	146	51
	Nairsa, or Dean's Island, (west end)	15	05	147	59
	Tikehau, or Krusenstern's Island, (N. pt.)	14	52	148	15
	Mataiwa, or Lazareff Island, (N. pt.)	14	52	148	42
	Metia Island, (N. pt.)	15	50	148	13
	Apataki, (N. pt.)	15	14	146	32
	Elizabeth, or Toau Island, (S. E. pt.)	15	58	145	49
	Sea-Gull group, — Tuinaka, or Ried, (south island)	16	40	144	10
	— Tipotu, or Bacon, (S. E. pt.)	16	44	144	03
	— Ohiti, or Clute, (S. W. pt.)	16	50	144	16
	St. Pablo, (centre)	19	53	144	59
	Archangel, or Heretua, (centre)	20	25	143	31
	Margaret's, or Nukutipipi, (centre)	20	42	143	04
	Four Crowns, or Teku, (centre)	20	28	143	18
	Taweree, or St. Simeon, or Resolution Isl. (S. pt.) (Isl. near Sandspit)	17	22	141	30
	Takurea, or Welcousky, (south island)	15	48	142	15
	Two groups, — Dauhaida, Manaka, —South pt. south island	18	13	142	10
	Tahiti, Har. of Papieti, (Motoutu Island)	17	31	149	34
Nav. I.	Rose Island	14	32	168	07
	Manua. (N. W. pt.)	14	13	169	29
	Ofoo, (N. W. pt.)	14	11	169	36
Navigator Isls.	Pago-Pago har., island of Tutuila	14	18 S	170	38 W
	Harbor of Apia, Island of Upolu	13	49	171	41
	Harbor of Mataalu, Island of Savaii	13	28	172	16
	Hoorn Island, (N. W. pt.)	14	15	178	02
	Uea, or Wallis Island	13	24	176	09
	Jarvis Island, (centre)	0	22	159	51
	Penrhyn's Island, (N. pt.)	8	55	158	07
	Wostock, or Stavers Island, (centre)	10	05	152	16
	Flint Island, (centre)	11	26	151	48
	Phœnix Group, — Birnie's Isl'd, (centre)	3	35	171	39
	— Enderbury's Island, (centre)	3	08	171	14
	— Hull's Island, (west end)	4	30	172	20
	Gardner's Isl'd, (centre)	4	38	174	41
	McKean's Isl'd, (centre)	3	35	174	17
	Union Group, — Otafu, or Duke of York Island, (N. W. pt.)	8	36	172	24
	— Nukunono, or Duke of Clarence Isl'd, (N. pt.)	9	05	171	38
	— Fakaafo, or Bowditch Island, (village)	9	24	171	06
	Swain's Island, (centre)	11	10	170	53
	Roaul, or Sunday Island, (centre)	29	12	178	15
Sandwich I.	Honolulu har., Oahu Isl.	21	19 N	157	52
	Lahaina har., Maui Isl.	20	50	156	41
	Waiakea har., Hawaii	19	44	155	03
	New York, or Washington Island, (west end)	4	42	160	13
	Necker Island, (centre)	23	35	164	43
	French Frigate School, or Basse de Fregate Française	23	45	165	59
		N. pt.		East end	
	Maro Reef	25	19	170	32
		S. pt.		East end	
	Smith Island, (centre)	16	48	169	46
Tarawan, or Kingsmill Group.	Taputeouea, or Drummond's Island, (Sandspit at Utivoa)	1	14 S	174	53 E
	Nanouti, or Sydenham Island, (N. pt.)	0	30	174	20
	Nanouki, or Hendervill Island, (S. pt.)	0	08 N	173	41
	Kuria, or Woodle Island, (South pt.)	0	17	173	26
	Apamama, or Hopper Island, (N. pt.)	0	30	173	54
	Maiana, or Hall's Island, (N. pt.)	1	02	173	04
	Tarawa, or Knox Island, (S. W. island)	1	22	173	01
	Apia, or Charlotte Island, (entrance)	1	48	173	02

Digitized by Google

TABLE LIV.

(CONTINUED.)

Latitudes and Longitudes.

		Lat. D. M.	Long. D. M.
	Maraki, or Matthew's Island, (N. pt.)	2 03 N	173 26 E
	Makin, or Pitt's Island, (S. pt.)	3 02	172 46
	Funafuti, or Ellice Island, (N. W. island)	8 26 S	179 14
	Nukufetau, or Depeyster's Island, (N. isl.)	7 56	178 28
	Oditupu, or Tracy Isl'nd, (centre)	7 28	178 44
	Hudson's Island, (N. pt.)	6 20	176 23
	Speiden's Isl'nd, (centre)	6 10	177 29
	St. Augustine, (centre)	5 35	176 06
	Walpole Island, (centre)	22 27	169 07
	Elizabeth Reef, (N. E. pt.)	29 34	159 24
	Mathews' Rock	22 27	172 10
	Macquarie's Isl'd, (S. pt.)	54 44	159 49
	Lord Auckland Group, (Sarah's Bosom)	50 34	166 27
Feejee Group.	Ovolau Island, (observatory)	17 41	178 53
	Lecumba point, (Sandalwood Bay)	16 52	178 35
	Muthuata har. (cemetery on Island)	16 26	179 04
	Unda pt. (east entrance Vanua Levu)	16 08	179 55 W
	Rewa Roads, (Nukalau Island)	18 10	178 32 E
Coral Sea.	Chesterfield Group— N. W. pt. Long Island	19 52	158 19
	Kenn Reef— Observatory, sand cay	21 16	155 49
	—— S. E. pt. of reef	21 15	155 50
	Frederick Reef— South Sand Islet	21 02	154 24
	North Sand Islet	20 57	154 26
	Saumarez Reef— S. W. sand cay	21 51	153 30
	S. E. elbow of reef	21 55	153 36
	Lihou Reef— N. E. point	17 21	152 06
	S. W. point	17 39	151 23
Barrier Reef, Australia.	Percy Group— Mid-Island, W. bay	21 40	150 17
	N. W. bay, S. islet	21 45	150 21
	Pine Peak	21 31	150 19
	Barrier Reef— Inside, No. 1 prong	22 09	152 12
	" No. 4 prong	21 29	151 10
	Outside, No. 1 prong	20 05	150 55
	" No. 3 prong	21 00	152 19
Feejee Group.	Tokanova pt. (S. E. pt. Vanua Levu)	16 46 S	179 56 E
	Direction Island, or Nemena	17 07	179 07
	Awakalo, or Round I.	16 41	177 43
	Malolo, (Avo Town)	17 46	177 07
	Vomo Island	17 29	177 14
	Kie Island	16 40	179 05
	Ongea Island	19 04	178 30 W
	Oneata Island	18 24	178 32
	Nanuku Island	16 42	179 26
	Turtle Island, (N. pt.)	19 47	178 25
	Pescadores Island, (east island)	11 23 N	167 37 E
	Korsakoff Island, (west island)	11 08	166 22
	Benham's Island, (south end)	5 47	169 36
	Hunter's Island, (centre)	5 42	169 06
	Bearing's Island, (centre)	5 35	168 26
	McKenzie's Island, (centre)	10 08	139 49
	Wake's Island, (centre)	19 17	166 32
Sooloo Sea.	Antique Roads, (Island of Panay)	10 40	122 00
	Caldera Roads, (Island of Mindanao)	6 56	122 01
	Soung Roads, (Island of Sooloo)	6 01	120 56
	Manghee Islands, (Balabac Straits)	7 30	117 19
California.	Bodegas Port	38 18 N	123 0.7 W
	San Francisco	37 47.8	122 21.2
	Monterey	36 37	121 50.8
	Santa Barbara	34 24.1	119 38.8
	San Pedro	33 43.2	118 13.8
	—— Juan	33 26.9	117 41
	—— Diego	32 41.1	117 11.3
	—— Quentin	30 21.9	115 56.5
	—— Bartolomeo	27 39.8	114 51.3
	Magdalena Bay North Pt. Entr.	24 32.3	112 1.2
	Observatory	24 38.3	112 6.3
	Cape St. Lucas	22 52.4	109 52.1

Digitized by Google

The shortest distance between two points on the earth's surface is on the arc of a great circle.

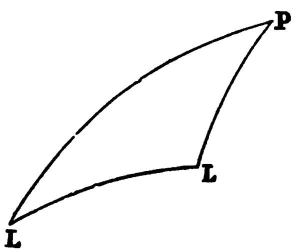
The following rules will enable the navigator to calculate the courses and distance, and to project the great circle track of the voyage, on the chart. By projection, the shortest distance between the two given points will be readily perceived.

The greatest difference between the tracks is found in the higher latitudes, and between points in about the same parallels. In crossing the equator, this difference, generally, is not of so much importance.

In Case I., we find the courses on the great circle to differ from the course on the rhumb line about two points. This difference, in many cases, is often more; the knowledge of which might be of great importance to the mariner, by enabling him to go on his course with a wind which on the rhumb line would be adverse.

The course on the rhumb line is always the same; on the great circle it is continually changing. It would be well to calculate the course two or three times during the day, working out the position of the ship by the usual methods.

A vessel sailing on the great circle track, on the same side of the equator, is always in a higher latitude than she would be on the rhumb line; consequently, in north latitude, the great circle line will be north of the rhumb line, and in south latitude, will be south of the rhumb line. This is evident on inspecting the annexed chart.



When the course found is greater than 90°, its supplement will be the course counted from the opposite pole. Thus, in Case V., the course is N. 131° 24′ E., or S. 48° 36′ E.

In calculating the courses PLL′ and PL′L, and the distance LL′, we have the two sides PL and PL′, and their included angle LPL′ given, the sides being the co-latitudes of the given places, and the angle P being the difference of longitude.

CASE I.

Given the latitudes and longitudes of two places on the same side of the equator, to find the courses.

By Theorems (8), (7), page 496, we obtain the following

RULE.

Make two columns, and write down the following logarithms. The log. cosine of half the difference of the latitudes in Col. 1, and the log. sine in Col. 2, the log cotangent of half the difference of longitude in both columns, the log. cosecant of half the sum of the latitudes in Col. 1, and the secant in Col. 2. The sum of the logs. in Col. 1 will give log. tangent of half the sum of the courses, and the sum of the logs in Col. 2 will give the log. tangent of half the difference of the courses. The sum of these results, rejecting 20 in the index, will give the course corresponding to the *greatest* latitude, and their difference the course corresponding to the *least* latitude.

EXAMPLE I.

Required the course from a point in the latitude 40° N. and longitude 70° W. to a place in the latitude 50° N. and 10° W.

Half the sum of the lats. = 45°. Half their difference = 5°. Half the difference of long. = 30°.

Col. 1.		Col. 2	
½ diff. lats. 5° ....cos.	9.99834	½ diff. lats. 5° ....sine	8.94030
½ diff. long. 30° ....cotang.	10.23856	Same......................	10.23856
½ sum lats. 45° ....cosec.	10.15051	½ sum lats. 45° ....secant	10.15051
½ sum courses, ...tang.	10.38741	½ diff. courses. ....tang.	9.32937
67° 43′		12° 03′	
12 03			

Course N. 79° 46′ W., from latitude 50° N.

Course N. 55° 40′ E., from latitude 40° N.

By Mercator's sailing, the course from 50° N. is S. 76° 42′ W., making a difference of 23° 32′.

When the places have the same latitudes, the sum of the logarithms in Col. 1 will be the log. tangent of the course from either place.

Digitized by Google

EXAMPLE II.

Required the course from a point in the latitude of 40° S. and 20° E., to another point in latitude 40° S. and longitude 80° E.

The half sum latitudes is 40°, the half difference is 0°, and half the difference of longitude 30°.

½ difference lats. 0°	cosine	10.00000
½ difference long. 30°	cotang.	10.23856
½ sum lats. 40°	cosec.	10.19193
Course, 69° 38′	tang.	10.43049

The courses are S. 69° 38′ E., or S. 69° 38′ W., and the difference between them and the Mercator course is 20° 22′.

CASE II.

Given the latitudes and longitudes of the two places, and the courses, to find distance.

Theorem (2), page 494, gives the rule.

RULE I.

Add together the log. sine of the difference of the longitude, the log. cosine of the latitude, the log. cosecant of the course; the sum, rejecting 20 in the index, will be the log. sine of the distance.

When the greatest latitude is used, the least course must be taken, and when the least latitude is used, the greatest course must be taken.

EXAMPLE I.

Let the latitudes and longitudes of the places be as in Example I., Case I., and the courses as therein found, 55° 40′ and 79° 46′. Required the distance.

Difference of long., 60°	sine	9.93753
Greatest latitude, 50°	cosine	9.80807
Least course, 55° 40′	cosec.	10.08314
Distance, 42° 23′	sine	9.82874
60		
2543 miles.		

By Theorem (10), page 496, we obtain

RULE II.

Add together the log. secant of half the difference of the two courses, the log. cosine of half the sum of the two courses, and the log. cotangent of half the sum of the latitudes; the sum, rejecting 20 in the index, will be the log. tangent of half the distance.

EXAMPLE II.

Given the parts as in the previous example. Required the distance.

½ difference courses, 12° 03′	secant	10.00968
½ sum courses, 67° 43′	cosine	9.57885
½ sum latitudes, 45°	cotangent	10.00000
½ distance, 21° 11½′	tangent	9.58853
2		
42° 23′ or 2543 miles.		

Distance by Mercator's sailing,......2608

Gain on the great circle,..............65

Use Rule II. when any doubt exists as to the result, which may be the case when the difference of longitude is about 90°.

Digitized by Google

EXAMPLE III

Required the distance between two points, one in 40° S. and 20° E., and the other in 10° S. and 80° E.; the course from each point being 69° 38′.

Difference long.,	60°	...............sine	9.93753
Latitude,	40°	...............cosine	9.88425
Course,	69° 38′	...............cosec.	10.02804
Distance,	45° 03′	...............sine	9.84982
	60		
	2703		

Distance by Parallel sailing, ...2758
" " great circle " 2703

Gain, ...55

CASE III.

Given the latitude and longitude of two places, to find the maximum separation in latitude.

In sailing between two places on the same side of the equator, on a great circle, the vessel always keeps in a higher latitude than on the rhumb line. The point on the great circle which is the greatest distance from the rhumb line, measured on the meridian, is the point of maximum separation in latitude.

RULE.

For the latitude. — Find the course between the places by Mercator's sailing, and take the supplement; also, the course on the great circle, from the same latitude; add together the log. cosecant of the Mercator course, the log. sine of the great circle course, and the log. cosine of the latitude of the place of the great circle course; the sum is the log. cosine of the latitude required.

RULE.

For the longitude. — Add together the log. secant of half the difference of the given latitude and the latitude just found, the log. sine of half the sum of the latitudes, and the log. tangent of half the sum of the great circle course, and the supplement of the Mercator course; the sum will be the log. cotangent of half the difference of longitude

EXAMPLE I.

Required the latitude and longitude of the point of the maximum separation between two points, one in the latitude 40° N. and longitude 70° W., and the other in latitude 50° N. and longitude 10° W.

By Case I., Mercator's sailing, we find the course,

As merid. diff. of lat., 851, ...	2.92993
Is to radius, ...	10.00000
So is the diff. of long. 3600, ...	3.55630
To tang. course, 76° 42′	10.62637

Its *supplement*, 103° 18′.

By Case I., Example I., we find the great circle course, from 40° N., to be 55° 40

To find the latitude.

Mercator's course, 76° 42′	..........cosecant	10.01181
Great circle course, 55° 40′	..........sine	9.91686
Latitude, 40°	..........cosine	9.88425
Latitude required, 49° 28′	..........cosine	9.81292

To find the longitude.

Lowest latitude, 40°, ...	40°	Supplement of Mercator course, ...	103° 18
Latitude of max. separation, ...	49° 28′	Great circle course, ...	55° 40
Sum, ...	89° 28′	Sum, ...	158° 58
½ sum, ...	44° 44′	½ sum, ...	79° 29
Difference, ...	9° 28		
½ difference, ...	4° 44		

Digitized by Google

½ diff. of latitudes,	4° 44	...........secant,	10.00148
½ sum of latitudes,	44° 44	.... sine,	9.84745
½ sum of courses,	79° 29′	.........tangent,	10.73133
½ diff. of longitude,	14° 44′	..........cotangent,	10.58026
	2		
Diff. of longitude,	29° 28′		
Longitude left,	70°		
	40° 32′ longitude of the required point of maximum separation.		

EXAMPLE II.

Required the latitude and longitude of the point of maximum separation in latitude, between two places, one in lat. 40° S. and 20° E., and the other in 40° S. and long. 80° E.

The courses found in Case I., Example II., is 69° 38′. The Mercator course is E., or W., or 90°, and its supplement, therefore, is 90°. Their half sum is 79° 49′.

For the latitude.

Merc. course, 90°.........cosec.	10.00000
Great circle co., 69° 38′....sine	9.97196
Latitude, 40°.............cosine	9.88425
Lat. required, 44° 06′......cosine	9.85621

For the longitude.

In this and similar cases of parallel latitudes, the difference of longitude will be equal to half the difference of longitude between the given places, which, in this example, is 30°, and the long. required, 50.°

CASE IV.

Given the latitudes and longitudes of the two places, and the great circle courses, to find the maximum latitude and its longitude.

When both courses, counted from the same pole, are less than 90°, then the maximum latitude of the arc will be within the two given points.

By Theorem (2), page 494, we get the

RULE

For the latitude.—Add the cosine of the latitude to the sine of the great circle course, from the same latitude; the sum, rejecting 10 in the index, will be the log. cosine of the maximum latitude.

By Theorem (1), page 494, we obtain the

RULE

For the longitude.—To the log. sine of the latitude, add the log. tangent of the corresponding great circle course; the sum will be the log. cotangent of the difference of longitude.

EXAMPLE I.

Given the latitudes and longitudes of two places, as in Example I., Case I.; viz: 40° N. and 70° W., and 50° N. and 10° W., to find the maximum latitude. The great circle courses are found, in Case I., to be 55° 40′ and 79° 46.

To find the latitude.

Lat. 40°..................cosine	9.88425
Course, 55° 40′............sine	9.91686
Lat. required, 50° 45½′.....cos.	9.80111

To find the longitude.

Latitude, 40°............sine	9.80807
Course, 55° 40′...........tang.	10.16558
Diff. long., 46° 44′........cotang.	9.97365
Long. left, 70°	
Long. req. 23° 16′ of the max. lat.	

When both places are in the same latitude, the maximum latitude and the point of maximum separation will be the same.

EXAMPLE II.

Required the maximum latitude between two points; one in lat. 40° S. and 20° E. and the other in 40° S. and 80° E.

In Case I., Example II., the great circle course is 69° 38′

To find the latitude.

Latitude, 40°	cosine	9.88425
Course, 69° 38′	sine	9.97196
Latitude, 44° 06′	cosine	9.85621

Being the same results as in Case III., Example II.

In this case, the longitude will be midway between the two given longitudes.

CASE V.

Given two places on the opposite sides of the equator, to find the courses and distance on an arc of the great circle.

Find the point of intersection of the great circle with the equator, by the following rule; then with this point, and the places given, proceed as in Cases I. and II. for the courses and distance.

RULE.

Add together the sine of the difference between the two latitudes, (not the difference of latitude,) the cosecant of the sum of the latitudes, and the tangent of half the difference of longitude; the sum, rejecting 20 in the index, will be the tangent of an arc X, which, added to half the difference of longitude, will give the difference of longitude between the greatest latitude and point of intersection.

EXAMPLE.

Given two points, one in 40° N. and 70° W., and the other in 30° S. and 10° W. Required the point of intersection of the great circle with the equator, and the courses and distance between the two given places.

The difference between 40° and 30° = 10°. The sum is 70°. Half the difference of longitude, 30°.

Difference between the lats.	10°	sine	9.23967
Sum of the latitudes,	70°	cosec.	10.02701
Half difference of long.	30°	tang.	9.76144
Arc X,	6° 05′	tang.	9.02812
Half diff. of long.	30°		
Diff. of long. from 40° N.	36° 05′		
Long. left,	70°		
Long. of intersection,	33° 55′ W.		

Having the latitudes 40° N. and 0°, and the longitudes 70° and 33° 55′, we can calculate the courses and distance by rules given in Cases I. and II.

To calculate the courses.

Half sum lats., 20°, and half difference of lats., 20°. Half difference long., 18° 03.

Col. 1.			Col. 2.		
½ diff. lats. 20°	cos.	9.97299	½ diff. lats. 20°	sine	9.53405
½ diff. longs. 18° 03′	cotang.	10.48694	Same,		10.48694
½ sum lats. 20°	cosec.	10.46595	½ sum lats. 20°	secant	10.02701
½ sum courses, 83° 14′	tang.	10.92588	½ diff. courses, 48° 10′	tang.	10.04800

48° 10′

Course N. 35° 04′ W. from the equator.

131° 24′

180° or

S. 48° 36′ E. from latitude 40° N.

To find the distance.

Difference of long. 36° 05′	sine	9.77009
Greatest latitude, 40°	cosine	9.88425
Least course, 35° 04′	cosec.	10.24069
Distance, 51° 45′	sine	9.89503

60

3105 miles.

Digitized by Google

To find the courses and distance from the equator, in long. 33° 55′ W., to 30° S. and 10° W.

Half sum lats., 15°. Half diff. of lats., 15°. Half diff. long., 11° 57′.

To find the courses.

½ diff. lats. 15° .... cos.	9.98494	½ diff. lats. 15° .... sine	9.41300
½ diff. long. 11° 57′ .... cotang.	10.67439	½ diff. long. 11° 57′ .... cotang.	10.67439
½ sum lats. 15° .... cosec.	10.58700	½ sum lats. 15° .... secant	10.01506
½ sum courses, 86° 45′ ... tang.	11.24633	½ diff. course, 51° 42′ ..... tang.	10.10245

51° 42′

Course S. 35° 03′ E. from the equator.

138° 27′
180°

N. 41° 33′ W. from 30° S.

To find the distance.

Difference long. 23° 55′ .... sine	9.60789
Greatest lat. 30° .... cosine	9.93753
Least course, 35° 03′ .... cosec.	10.24087
Distance, 37° 41′ .... sine	9.78629

60

2261 miles.

CASE VI.

To project the track on a great circle.

First, (by Raper.) When the places are on the same side of the equator.— Draw the line connecting the given places, find the position of the point of the maximum separation of latitude, and through this point draw a line parallel to the line connecting the two places. Find the courses on the great circle from the two places, and draw them on the chart. We can, through these three points, roughly trace the required curve. If the maximum latitude falls on the curve, we shall have a fourth point.

EXAMPLE I.

Given the latitudes 40° N. and 50° N., and their corresponding longitudes 70° W. and 10° W., to project the great circle track connecting them.

By Case I., the courses are found to be N. 55° 40′ E., and N. 79° 46′ W., and by Case III., the position of the point of maximum separation of latitude is found to be 49° 28′ N. and 40° 32′ W.; and by Case IV., the maximum latitude is in 50° 45½′ N., and 23° 16′ W.

Draw on the chart the line AB, connecting the two points; from A and B, lay off the courses N. 79° 46′ W., and N. 55° 40′ E.; through the point of maximum separation draw a line parallel to AB; through these points, and the point of maximum latitude, draw the dotted line, which will be the track required.

Second.— When the places are on opposite sides of the equator.— Find the course at each of the given points, and the points of maximum separation of latitude, for both sides of the equator; find the longitude of the intersection of the great circle with the equator, and the course at that point; with these five points, construct the track.

EXAMPLE II.

Given two places, one in the latitude 40° N. and longitude 70° W., and the other in 30° S. and 10° W., to project the track on the great circle, passing through them.

The courses are, by Case V., N. 41° 33′ W., from 30° S., and S. 48° 36′ E., from 40° N. The longitude of the intersection of the great circle on the equator, by Case V., is 33° 55′ W., and the course at the intersection is N. 35° 03′ W., and S. 35° 03′ E.

The maximum separation of latitude north of the equator, is in 25° 33′ N. and 53° 31′ W.; and south of the equator, is in 18° 21′ S. and 20° 31′ W.

With these points, the great circle track can be constructed, as in the example preceding.

Digitized by Google

EXAMPLE III.

Given one place in the latitude 40° S. and 20′ E., and another in 4(S. and 80° E., to project the track.

By Case I., Example II., we find the courses to be S. 69° 38′ E., and S. 69° 38′ W.

By Case III., Example II., the maximum separation of latitude is in 44° 06′ S. and longitude 50° E.

By Case IV., Example II., the maximum latitude in this case is the same as the maximum separation of latitude.

With these three points, the track can be easily drawn.

The great-circle track, from Cape Clear to the northern portion of the United States passes so near Cape Race, that mariners, in endeavoring to keep on this track, are often placed in great peril when approaching the vicinity of Newfoundland.

The following track, from Cape Clear, passing through a point one hundred miles south-east of Cape Race, and thence to Nantucket South Shoal, by *Mercator's sailing*, is proposed:

	Lat. N.	Long. W.	Lat. N.	Long. W.
1st. From Cape Clear, in - - -	51° 26′ and	9° 29′, to	51° 16′ and	23° 27′.
2d. From	51° 16′ and	23° 27′, to	49° 23′ and	37° 24′.
3d. From	49° 23′ and	37° 24′, to	45° 28′ and	51° 21′.
4th. From 100′ S. E. of Cape Race,	45° 28′ and	51° 21′, to	41° 04′ and	69° 51′.

The distance on these four courses, by *Mercator's sailing*, is - - -	2532¼
The distance on the *Great Circle*, from Cape Clear to a point 100 miles S. East of Cape Race, and thence to Nantucket South Shoal, is - - - - - -	2528
Making a saving of only about - - - - - - - - - - - - -	4¼

The distance on the great circle, direct from Cape Clear to Nantucket South Shoal, is, 2505
Being only 27¼ miles less than the route proposed.

In sailing easterly beyond the Cape of Good Hope, we have (by Example III., page 454) the distance by parallel sailing - - - - - - -	2758 miles,
And by great-circle sailing - - - - - - - - - - - -	2703 "

Now, if by Mercator sailing, we lay off the track
From 40° S. and 20° E. to 44° 06′ S. and 50° E. and thence
From 44° 06′ S. and 50° E. to 40° S. and 80° E., we shall find the distance 2722 "
Only 19 miles more than the great circle.

From these examples, it would seem that the advantages in most cases derived from keeping on the great-circle track, are not sufficient to authorize the mariner to run the least risk in pursuing his course; and that the small saving of distance is not really of any comparative importance.

Digitized by Google

ON THE COMPASS.

The British Admiralty have directed that Compasses should be placed at least 4 feet 6 inches apart on board of the ships of war. This is to avoid the disturbance known to exist when two needles are placed near each other. The error from this source has, in some cases, amounted to more than 8°. It is to be hoped that the mercantile interest of the country will adopt this rule. If the steering apparatus is sufficiently small one compass is strongly recommended, a standard compass, for reference, being placed on the centre line of the ship.

No Iron should be allowed within *seven* feet, and *vertical Iron stancheons*, &c., should be at least fourteen feet from the compasses.

Binnacles should be made without doors, to prevent improper substances from being placed therein.

The common compasses are frequently very imperfectly constructed, and the needles poorly magnetized. Great care in their selection cannot be too strongly recommended; they should, like the chronometer, *be carefully handled*, and not subjected to the rough usage they frequently receive.

Rules for ascertaining the deviation of the compass caused by the Iron in the ship.

1st.—A good standard compass should be placed on the centre line on the quarter deck, as far as possible from all masses of Iron. It should have such a support as will render bearings and amplitudes easily taken.

2d.—Bearings should be taken *only on that part of the ship where the standard compass is placed*, or *where the observations for deviation* were made.

3d.—When the ship is *fully ready for sea*, *with every thing on board*, allow her head to come up successively to the thirty-two points of the compass; then accurately observe the bearing of *some distant* but well defined object, (the real magnetic bearing of the same having been ascertained,) and record the same as in Table I.

4th.—The real magnetic bearing may be found by taking the standard compass on shore and placing it on a line with the object observed and that part of the ship where the compass stood, so that they shall be in a line with the observers eye. The difference between this real magnetic bearing and the bearing in col. 2 will give the deviation which is found in col. 3.

TABLE I.

Real magnetic bearing of the *distant object* from the ship, N. 80° E.

Ship's Head by the Standard Compass.	Bearing of by the Standard Compass.	Deviation of the Standard Compass.	Ship's Head by the Standard Compass.	Bearing of by the Standard Compass.	Deviation of the Standard Compass.
North.	N. 81° E.	1° W.	South.	N. 80° E.	Nothing.
N. by E.	N. 79 E.	1° E.	S. by W.	N. 81° E.	1° W.
N. N. E.	N. 78 E.	2° E.	S. S. W.	N 82° E.	2° W.
N. E. by N.	N. 76 E.	4° E.	S. W. by S.	N. 83° E.	3° W.
N. E.	N. 75 E.	5° E.	S. W.	N. 84° E.	4° W.
N. E. by E.	N. 74 E.	6° E.	S. W. by W.	N. 85° E.	5° W.
E. N. E.	N. 73 E.	7° E.	W. S. W.	N. 86° E.	6° W.
E. by N.	N. 72 E.	8° E.	W. by S.	N. 87½ E.	7½ W.
East.	N. 72½ E.	7½ E.	West.	N. 87° E.	7° W.
E. by S.	N. 73 E.	7° E.	W. by N.	N. 86½ E.	6½ W.
E. S. E.	N. 74 E.	6° E.	W. N. W.	N. 86° E.	6° W.
S. E. by E.	N. 75 E.	5° E.	N. W. by W.	N. 85° E.	5° W.
S. E.	N. 76 E.	4° E.	N. W.	N. 84° E.	4° W.
S. E. by S.	N. 77 E.	3° E.	N. W. by N.	N. 83° E.	3° W.
S. S. E.	N. 78 E.	2° E.	N. N. W.	N. 82° E.	2° W.
S. by E.	N. 79½ E.	0½ E.	N. by W.	N. 81° E.	1° W.

The deviation is *East* when the north end of the needle is drawn to the eastward.

Digitized by Google

or right hand; and *West* when the north end of the needle is drawn to the westward, or left hand.

EXAMPLE:—When the ship's head is E. by N. the bearing by the standard compass was N. 72° E., it follows that the north end of the needle has been attracted 8° to the eastward.

Should there be no proper object of sufficient distance visible from the ship, then a second compass must be taken on shore, and the bearing of the two compasses from each other observed at each of the thirty-two points, and the results registered as in Table II. The standard compass should be compared on shore with the second compass, and if any difference is found it should be noted.

TABLE II.

Ship's Head by the Standard Compass.	Bearing of the Shore Compass from the Standard Compass.	Bearing of the Standard Compass from the 2d Compass on shore with the correction for their difference applied.	Deviation Standard Compass.	Correct Magnetic Course.
N.	S. 31° W.	N. 30 E.	1° W.	Nearly N.
N. by E.	S. 28½ W.	N. 29½ E.	1° E.	N. 12° E.
N. N. E.	S. 27° W.	N. 29° E.	2° E.	N. 24° E.
&c.				

Col. 5th gives the correct magnetic course, and also the points, when the iron causes the least deviation, which generally are the North and South points; but as this is not always so, especially for steam vessels, we should depend upon observations only.

The points once established may be considered permanent, provided every thing remains the same and the compass used in the same place.

An azimuth at sea, with the ship's head on the point of no deviation, will give the true variation.

The amount of deviation varies with the latitude, and in southern latitudes it becomes important to form new tables, as the deviation generally changes from West to East and from East to West. The deviations can be examined at sea, by observing azimuths with the ship heading on different points, especially on the point of no deviation. If the results conform to the table they may continue to be used; if not, then a new table should be made.

The standard compass in iron vessels should be raised above the deck much higher than in sailing vessels.

In steam vessels with telescopic funnels the deviation is sensibly affected when they are taken down. Observations should be made when up and down.

It is recommended that the ship should be *directed by the standard compass*, and the binnacle compass should be used by the helmsman only to give the approximate course. Direct reference should be frequently had to the standard compass

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

Digitized by Google

UNIVERSITY OF MICHIGAN
3 9015 06819 1645

Astro
VK
555
.A512
1880

Digitized by Google

Digitized by Google